Physics Lesson Plans For
Conventional Method

Lesson No. 1
Topic: Heat

Instructional objectives:
After the instruction is over, students will be able to:
(1) name the ways of heat transfer (conduction, convection and radiation)
(2) explain conduction,
(3) explain convection
(4) explain radiation.
(5) explain heat equilibrium

Prerequisite knowledge of students:
It is assumed that students can differentiate between various matters. They must know some concepts such as: molecule, energy, flow, area, and density. They must also have learnt molecule motion theory.

Instructional aids:
Some materials such as bars of different kinds, matches sticks, Vaseline, trivets, and laboratory flames are needed to do related experiment.

Content sequence:
(1) Heat can be transferred through molecules by different ways like conduction, convection and radiation.
(2) Heat transfer is called conduction, when heat flows in a matter without its movement.
(3) Heat transfer is called convection, when heat flows in a matter through its movement.
(4) Heat transfer is called radiation, when heat reaches a matter from a light source through vacuum.
(5) Heat transfer continues till heat equilibrium takes place.

Instructional program:

Content sequence (01)
Teacher tells the students: “we learn today something about heat.”
Teacher asks; “If you put a pan having an iron handle on the flame of gas stove, what will happen after a few minutes?”
Students answer the teacher.
Teacher says: “There are mainly three ways of heat transfer, i.e. conduction, convection and radiation.
Content sequence (02)
Teacher asks students to do an experiment. They are asked to put three bars on a trivet. These bars must be of different materials like iron, glass, and wood, but with same length and thickness. Subsequently they are to fix a matches stick with the help of candle or Vaseline to the head of each one of these three bars. Then they are asked to give heat to the end of bars by help of a low flame for a while.
Teacher asks: "Why do the matches sticks fall down?" and "why do they fall down at different intervals of time?"
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: "This experiment shows that heat flows in these bars and because these bars are solid and their molecules can not be displaced, heat flows in them without movement of matter.
Teacher says: "Heat transfer is called conduction, when heat flows in matter without its movement. Some materials transfer the heat very fast, they are good conductors of heat like iron bar and some materials transfer the heat very slow, they are bad conductor or nonconductor like glass or plastic. Water and air are also weak and very weak conductors of heat respectively.

Content sequence (03)
Teacher tells the students: "Another way of heat transfer as I told you earlier is convection. If we make a glass container full of water and set some permanganate's potassium crystals in water when it is stable, and then with the help of a flame, give the container heat right under the crystals, we will see that violet streams along with warm water come up and then are forced to go down in the other side of container. Thus water rotates in the container. This process is also same in case of air.
Teacher asks: "can you explain the cause of this process?"
Students answer the teacher.
Teacher confirms or corrects and explains.

Content sequence (04)
Teacher tells the students: "Sunlight increases the temperature of objects. Light passes through vacuum to reach us. This type of heat transfer does not need material settings or molecules for transferring the heat. Such heat transfer is called radiation, when heat reaches matter from a light source (such as sun, fire, or lamp) through vacuum.
Teacher asks: "Do you know how the objects which received heat through light lose their temperature?"
Students answer the teacher.
Teacher confirms or corrects and explains how objects emit, reflect, and absorb the heat.
Content sequence (05)
Teacher asks: “Do you remember the molecule motion theory?”
Students answer the teacher.
Teacher tells the students: “As you know, according to this theory molecules are in motion with different speed and consequently with different energies. They have also potential energy. Internal energy of an object is equal to sum of kinetic and potential energy of total molecules of that object. The average kinetic energy of a molecule is equal to total kinetic energy of molecules of an object’s divided by number of its molecules. When the temperature of an object is increased, the average kinetic energy of its molecule is increased too. The average kinetic energy of molecules of two different objects having same temperature is same.
Teacher tells the students: “Let me give an example. If you take a glass of water from a pool, the average kinetic energy of its molecules is same as the average kinetic energy of molecules of pool’s water, but since the numbers of molecules in the water of glass and pool are different, they don’t have same kinetic and also internal energies. The internal energy of water in glass is lower than water in pool.
Teacher tells the students: “We go back to the heat transfer. When you put a hot iron press on the cloth, the temperature of cloth is increased. Even the temperature of the table under the cloth is increased more than cloth itself. The internal energy of iron press is decreased and internal energy of cloth is increased in this process. When you unplugged the iron press, heat transfer continues, till heat equilibrium takes place. Although the internal energy of iron press may be more than internal energy of cloth, but the essential factor in heat energy transfer is temperature difference.

Formative evaluation
(1) Name different ways of heat transfer.
(2) Explain each way of heat transfer.
(3) Name the materials used in making stands and handles of kitchen utensils and explain why this kind of materials are used?
(4) When you open the fridge’s door, cold air comes out from bottom of fridge. Why?
(5) Why white color is used to dye the outer sides of houses in tropical area?

Home assignment
Find some new examples for explaining the different ways of heat transfer.
Lesson No. 2

Topic: Heat

Instructional objectives:
After the instruction is over, students will be able to:
(1) explain heat equilibrium and measurement of temperature.
(2) explain the temperature scales.
(3) explain how to estimate heat amount.
(4) explain the specific heat capacity.

Prerequisite knowledge of students:
It is assumed that students are aware of various ways of heat transfer. They must know some concepts such as: properties of matter, pressure, molecule motion, internal energy, kinetic and potential energy, and average kinetic energy.

Instructional aids:
Some thermometers are needed in addition to chalk and blackboard.

Content sequence:
(1) Heat equilibrium and thermometry
(2) Temperature scales
(3) Heat amount estimation
(4) Specific heat capacity

Instructional program:

Content sequence (01)
Teacher asks students: “Do you remember the explanation of heat equilibrium?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher tells the students: “we learn today something about the relationship between heat equilibrium and thermometry.”
Teacher explains: “Perhaps you are familiar with medical thermometer. These thermometers are usually made of a glass pipe containing mercury (quicksilver). When your body’s temperature and temperature of thermometer’s mercury are not same, suppose your body’s temperature is higher, the average kinetic energy of molecules of your body is higher than that of thermometer’s mercury. Your body’s molecules in contact with thermometer’s molecules transfer some of their kinetic energy to the latter. So, the internal energy of thermometer will be increased subsequently. This
transmission is continued till equilibrium takes place between average kinetic energy of molecules of your body and that of thermometer.”
Teacher concludes: “when two objects are in a state of heat equilibrium, the amount of heat energy which exchange between them is same and these two objects are of same temperature.
Teacher asks: “Could you now conclude the cause of heat transfer?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher says: “Now, you know that temperature difference between two objects causes the heat transfer between them. Whatever we measure in thermometry is this difference. So the temperature degree is a relative quantity.”
Teacher asks: “Could you now explain what will happen when the temperature of an object is changed?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher tells the student: “We can use these changes in properties of matter as a criterion for measuring the temperature.”

Content sequence (02)
Teacher explains: “Two stable or fixed temperature points (like freezing and boiling points of water) are needed for grading the thermometer. These are fixed points of thermometry. We attribute an arbitrary fixed point to each one of these two points and then we divide the range of temperature between these two points into equal parts. The number of these parts or points must be equal to difference between two fixed points. Each part or point is called the temperature unit.
Teacher asks: “Could you now tell me how many kinds of temperature scale you have dealt with?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: “The lower fixed point in Celsius scale is the temperature of melting (pure) ice (in pressure of one atmosphere). This point is called 0°C. The upper fixed point is the temperature of steam right over the evaporating (pure) water (in pressure of one atmosphere). This point is called 100°C. The range between two fixed points has been divided into 100 units. Each unit is equal to one degree Celsius.”
Teacher says: “there is not any highest point for temperature, for example, the internal temperature of sun is 15° million Celsius. There are also other stars with higher degree of temperature. But there is a lowest degree for temperature, which is -273°C. It is called absolute zero. In this state, the internal energy of an object reaches its least possible amount. The temperature scale with absolute zero is called Kelvin scale, commemorating its inventor. One point on Kelvin scale is called one Kelvin. It is also equal to one unit in Celsius scale. So, the 0°C and 100°C are equal to -273 and 273 Kelvin respectively. Now, you can return the
Celsius values to Kelvin values and vice versa, through this simple formula; \( T = \theta + 273 \), while \( T \) stands for (absolute) temperature, \( \theta \) stands for temperature on Celsius scale.

**Content sequence (03)**

Teacher says: "Suppose we have two similar vacuum flasks, one containing 1kg and the other 2kg of water. Two thermometers show 10°C for both. We increase their temperature to 60°C by the help of heaters having same configuration. It is observed that the time duration to do this action for second flask containing 2kg of water is almost double in comparison with first one. As I told you, heaters are same and they transfer same heat energy within the same time.

Teacher concludes: "Therefore, the heat energy which has been transferred to 2kg of water is twice of the heat energy which has been transferred to 1 kg of water. That means the heat energy \( (Q) \) needed to change the temperature of some water is related to its mass \( (m) \). So this statement is right in case of other materials. Thus we can write \( Q \propto m \).

Teacher asks: "Could you tell me about transferring the heat energy to different kind of materials having same mass and same temperature, like 1kg of water and 1kg of cooking oil?"

Students answer the teacher.

Teacher confirms or corrects.

Teacher concludes: "The heat energy \( (Q) \) needed to change the temperature of different objects is related to both their mass \( (m) \) and also their types. By types, we are referring to a special quantity, which is called specific heat capacity \((c)\). Experience shows whenever more changes of temperature of an object \( (\Delta T = \Delta \theta) \) are intended; the needed heats for obtaining desirable changes are higher. Suppose if we want to increase the temperature of 1kg water from 10°C to 30°C, we need heat energy two times more than when we want to increase its temperature from 10°C to 20°C. Therefore, the needed heat to change the temperature of an object depends also on its present temperature. So we can write \( Q = \Delta T \).

**Content sequence (04)**

Teacher asks: "Could you explain the concept of specific heat capacity?"

Students answer the teacher.

Teacher confirms or corrects.

Teacher says: "Specific heat capacity \((c)\) of an object is the heat energy amount needed to change \((1\,\text{C} \text{ or } 1 \text{ Kelvin})\) temperature of one unit of its mass. The unit for specific heat capacity is joule over kilogram. Kelvin \( \frac{J}{kg\text{K}} \). The Specific heat capacity is one of the physical properties of each matter, and its value is almost fixed. You can check out specific heat capacity \((c)\) of some matters in the related table in your textbook. Now, we
can conclude that three factors are involved in changing the temperature of an object; i.e., the mass of object (m), The specific heat capacity (c) of the object in terms of \( \frac{J}{\text{kgK}} \), and finally the desirable amount of temperature change (\( \Delta T \)).

**Formative evaluation**

1. Why should glass wall of the reservoir of thermometer be thin?
2. Why the water is suitable liquid to make the automobile engine cool?
3. How could you measure the specific heat capacity of an object?
4. What does the statement: “The specific heat capacity of water is 4200 \( \frac{J}{\text{kgK}} \)” means?

**Home assignment**

Solve the problems, which have been given at the end of the chapter.
Lesson No. 3

Topic: Heat

Instructional objectives:
After the instruction is over, students will be able to:
(1) explain expansion in solids.
(2) calculate the linear expansion.
(3) calculate the superficial expansion.
(4) calculate the voluminal or cubic expansion.
(5) explain the expansion in liquids.

Prerequisite knowledge of students:
It is assumed that students are aware of various ways of heat transfer. They must also have learnt the followings: relation between heat equilibrium and thermometry, temperature scales, heat amount estimation, and specific heat capacity.

Instructional aids:
Some metal circles and balls are needed to do experiment, in addition to chalk and blackboard.

Content sequence:
(1) Expansion in solids.
(2) Linear expansion
(3) Superficial expansion
(4) Voluminal or cubic expansion
(5) Expansion in liquids

Instructional program:

Content sequence (01)
Teacher explains: “Whenever the object’s temperature is increased, its volume also is increased, and vice versa. Now you must do the metal circle and ball experiment.”
Teacher guides the student during experiment.
Teacher asks students: “Why the metal ball does not pass through circle after its temperature is increased?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher asks students: “Do you know why does this happen?”
Students answer the teacher.
Teacher confirms or corrects.

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Teacher explains: “The cause of expansion is that when the temperature of an object is increased, its molecules obtain additional energy. Therefore they vibrate faster and need more space for movement. Thus each molecule tries to push away its neighboring molecule, despite of attractiveness between molecules. So, in case of most of the solid matters, the gap between molecules is increased following temperature upsurge and causes the expansion.

**Content sequence (02)**

Teacher explains: “The expansion size is not same in different solid matters. We define a quantity called linear expansion ($\alpha$) to show this difference. The linear expansion ($\alpha$) is equal to length enhancement of one unit of matter's length in lieu of 1K temperature.”

Teacher writes on the blackboard: The linear expansion of a bar depends on three factors; (1) initial length of bar ($L_I$), (2) the amount of changes of temperature ($\Delta T$), and (3) the linear expansion of the matter which the bar is made of, ($\alpha$). Therefore, when the temperature of a bar with $L_I$ length is increased by $\Delta T$, its length will be increased by $\Delta L$. Thus for $\Delta T$ temperature upsurge, the length unit's expansion of bar is $\frac{\Delta L}{L_I}$. If the temperature of the length unit's of a bar is increased by 1K, its length unit will be expanded by $\frac{\Delta L}{L_I\Delta T}$. This is the very linear expansion itself, $\alpha = \frac{\Delta L}{L_I\Delta T}$ or $\Delta L = \alpha L_I \Delta T$.

Teacher says: “you can know check out the linear expansion of some materials in the related table in your textbook.”

**Content sequence (03)**

Teacher explains: “The superficial expansion of a solid matter ($2\alpha$) is equal to area upsurge of one unit of matter’s area in lieu of 1K temperature. We can show that the superficial expansion of an object is twice more than its linear expansion.”

Teacher writes on the blackboard: $\frac{1}{k} = \frac{m^2}{m^2K}$, while $\frac{1}{k}$ is superficial expansion, the upper $m^2$ stands for area upsurge of superficial unit, the lower $m^2$ stands for initial area size and $K$ stands for temperature upsurge. This is the very superficial expansion itself, $2\alpha = \frac{\Delta A}{A_I \Delta T}$ or $\Delta A = 2\alpha A_I \Delta T$.

**Content sequence (04)**

Teacher explains: “The voluminal expansion of a solid matter ($\beta$) is equal to volume upsurge of one unit of matter’s volume in lieu of 1K
temperature. We can show that the voluminal expansion of an object is three times more than its linear expansion, i.e., $\beta = 3\alpha$.

Teacher writes on the blackboard: $\frac{1}{k} = \frac{m^3}{m^3 K}$, while $\frac{1}{k}$ is voluminal expansion, the upper $m^3$ stands for volume upsurge of voluminal unit, the lower $m^3$ stands for initial volume size and $K$ stands for temperature upsurge. This is the very voluminal expansion itself, $\beta = \frac{\Delta V}{V_1 \Delta T}$ or $\Delta V = \beta V_1 \Delta T$.

Content sequence (05)
Teacher explains: “Suppose, just like the picture in your textbook, there is a glass balloon full of colored water and its mouth is closed with a lid having a connected glass pipe, so that there is not any air in the balloon and water is standing a little upwards in the connected pipe.”
Teacher asks students: “What will happen if you put this balloon in a hot liquid, so that it receives steady heat?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: “The water level comes down in the pipe at initial few seconds of heating. Since glass is a weak conductor, glass balloon is expanded first and its internal volume is increased. The liquid, which is not expanded, yet comes down to fill up this extra volume in the balloon, but as soon as heat reaches the liquid, its expansion will begin and the liquid level will go even higher than its initial level. This shows that voluminal expansion of liquids is high and liquids are expanded much more than solids, but this expansion is apparent expansion of liquid. The actual expansion is more than apparent expansion. Actual expansion is equal to total apparent expansion plus voluminal expansion of container.”
Teacher concludes: “The expansion of a liquid is equal to volume upsurge of one unit of liquid’s volume in lieu of $1K$ temperature. We can calculate the volume changes of a liquid through the following formula.”
Teacher writes the formula on the blackboard: $\Delta V = \beta V_1 \Delta T$.
Teacher says: “Now you can find out the expansion of some liquids by temperature degree between 0 and 50, in the related table in your textbook.

Formative evaluation
(1) Why is it easier to remove the metal cap of a glass jar after pouring some hot water on it?
(2) If you pour suddenly some hot water in a glass, it is possible for glass to be broken. So, in order to reduce this possibility which one of following suggestions is better? And why?
Glass must be made of thin glass.
Glass must be made of thick glass.

Home assignment
Solve the problems, which have been given at the end of the chapter.
Lesson No. 4

Topic: Heat

Instructional objectives:
After the instruction is over, students will be able to:
(1) name the various changes in matters status.
(2) explain the fusion.
(3) explain the surface evaporation.
(4) explain the surface evaporation and boiling.
(5) explain the expansion in gas.
(6) explain the Charles – Giulisick formula
(7) explain the Boil-Marriott law.
(8) explain the gas status equation.

Prerequisite knowledge of students:
It is assumed that students are aware of various ways of heat transfer, relation between heat equilibrium and thermometry, temperature scales, heat amount estimation, specific heat capacity and finally the expansion of matters.

Instructional aids:
Chalk and blackboard and a large size diagram of relationship between volume and temperature in gas are needed.

Content sequence:
(1) Possible changes of matter
(2) Fusion
(3) Surface evaporation
(4) Surface evaporation and boiling
(5) Expansion in gas
(6) Charles – Giulisick formula
(7) Boil-Marriott law
(8) Gas status equation

Instructional program:

Content sequence (01)
Teacher explains: “Here are some possible changes of materials resulting from temperature change. Solid transformation into liquid is called fusion; liquid transformation into vapor is called evaporation; liquid transformation into solid is called solidification; and vapor transformation into liquid is called condensation.”
Teacher asks students: could you give me some examples regarding these possible changes?"
Students answer the teacher.
Teacher confirms or corrects.

Content sequence (02)
Teacher explains: “When a solid receives heat, its temperature is increased. When this temperature reaches a certain point, it remains stable and the fusion of solid is started. This temperature point is called fusion point, which is also depend on the quality of object and the pressure, which is imposed on it. The upsurge of pressure causes the upsurge of fusion point, but this is not right in few cases like ice.”
Teacher continues: “Fusion process is heat consumer. The heat amount, which is received by solid at fusion point, does not change its temperature, but merely it is consumed to convert the status of object. Hence this heat amount is called latent heat of fusion. Giving the latent heat of fusion to a solid which has already reached its fusion point, results in its fusion. Getting the latent heat of fusion of a liquid, which has been already, reached its solidification point, results in its solidification.”
Teacher concludes: “The fusion point temperature of a matter is same as its solidification point temperature provided the same conditions persist. So if we give 1°C heat (which is fusion point of ice in 1 atmosphere pressure) to the ice, it begins to melt and if we get 1°C heat from water, its solidification will start.”
Teacher writes on the blackboard: The specific latent heat of fusion (L_f) of a solid is equal to the amount of the needed heat energy to convert a unit (1kg) of its mass to liquid, but not to change its temperature. So the needed heat for fusion of m grams of a solid can be calculated through this formula. Q=mL_f.

Content sequence (03)
Teacher asks students: “What do you think will happen to molecules of a liquid during the evaporation?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: “It is possible for those molecules that reach to surface of liquid to exit or return to it. Actually the molecules are escaping from each other, because they have the needed energy to escape from molecular attraction. Escape of speedy molecules and the remaining of slower molecules results in average energy reduction of liquid’s molecules. The temperature of a liquid, which has slower molecules with lower kinetic energy, is lower.”
Teacher concludes: “When the heat energy is given to a liquid to help its evaporation, actually the more molecules are receiving sufficient kinetic energy to escape. The evaporation process is heat consumer and liquid
receives the given energy to enable the molecules to escape from the liquid’s surface. The surface evaporation rates depends on three factors; (a) upsurge of liquid’s temperature; (b) upsurge of area of liquid’s surface; and (c) blowing the wind over the liquid’s surface.

Teacher asks students: “Could you interpret this final conclusion?”

Students answer the teacher.

Teacher confirms or corrects.

**Content sequence (04)**

Teacher explains: “Surface evaporation and boiling, both cause liquid evaporation. When a liquid reaches boiling point, we can see that bubble formation and simmering takes place inside that liquid. There is also another difference between boiling and surface evaporation. Evaporation takes place on liquid’s surface and at any level of temperature, but boiling takes place only when a liquid reaches at a certain level of temperature, which is called boiling point. The boiling point of each liquid depends on its quality or type and the pressure, which is imposed on it.”

Teacher asks students: “Could you say why is the food cooked faster in steam cooker than any other usual pan?”

Students answer the teacher.

Teacher confirms or corrects.

Teacher continues: “The heat amount, which is received by a liquid at its boiling point, does not change its temperature, but merely it is consumed to convert the status of liquid into the steam. Hence this heat amount is called latent heat of evaporation. Giving the latent heat of evaporation to a liquid at its boiling point, results in its evaporation and getting the latent heat of evaporation from a steam results in its condensation. Heat must be given to a liquid, if it is to convert to steam. The liquid may get this needed heat for evaporation from its surrounding area.”

Teacher asks students: “Could you say why do you feel cool, when you come out from pool during summer, though the weather is hot?”

Students answer the teacher.

Teacher confirms or corrects.

Teacher writes on the blackboard: The specific latent heat of evaporation ($L_v$) of a liquid is equal to the amount of the needed heat energy to convert a unit (1kg) of its mass to steam, but not to change its temperature. So the needed heat for evaporation of m grams of a liquid can be calculated through this formula. $Q = mL_v$.

Teacher says: “Now, you are familiar with two formulas.”

Teacher writes on the blackboard: (1) $Q = mc\Delta T$, (2) $Q = mL$.

Teacher says: “The heat energy, in case of first formula, i.e., $\Delta T$ causes the change in temperature without changing physical status of matter, whereas the heat energy, in case of second formula, causes the change in physical status of matter without changing its temperature. The unit for specific latent heat ($L_F$ or $L_v$) is joule over kg; J/kg.”

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Teacher asks students to solve two related problems.

Content sequence (05)
Teacher explains: “When a gas receives heat, its molecules acquire more kinetic energy and therefore move faster towards every side. This change of energy appears in form of temperature upsurge of the gas. Rise of energy in molecules of gas causes the rise of its volume and its pressure both. The gas laws describe the results of experiments, which are conducted to specify the relationship between temperature, pressure, and volume in gas. Gas laws are applicable for certain amount of mass of the gas and explain the relationship between gas temperature, pressure, and volume of behavior of a fixed number of molecules of gas. In the other words, we assume that when gas gets warm or compressed, neither any molecule is added to the number of its molecules, nor it is reduced.”
Teacher says: “You must know the following facts concerning gas expansion. First, gas molecules have random movement. Second, when the speed of this movement is stable, it sounds that the gas temperature is stable. Third, rise in temperature, at a fixed pressure level, causes the gas expansion. Fourth, rise of pressure, at a fixed level of temperature, decreases the gas volume.”

Content sequence (06)
Teacher says: “The relation between gas temperature and its volume at a fixed pressure level, was investigated for the first time by French scientists, i.e., Charles and Giulsick. The Charles – Giulsick formula regarding temperature-volume relation for all gases suggest that the volume of all gases must be 0 at -273°C (absolute zero for temperature), But all gases converted into liquids at low temperature and therefore we can not consider 0 value for gas volume. However, we can conclude the Charles – Giulsick law very easy, by looking at temperature-volume diagram (which is also given in your textbook), you observe that whenever the absolute temperature of a gas on Kelvin scale (T) is increased twice, the gas volume is also increased twice. The Charles – Giulsick law state this relation as follow; the volume of a certain amount of gas has direct relation with its absolute temperature at a fixed pressure level. So, the formula is this.”
Teacher writes on the blackboard: \[ V \propto T, \quad \text{or} \quad V = \text{fix value} \times T \quad \text{or} \quad \frac{V}{T} = \text{fix value}. \]
Teacher asks students to solve two related problems.

Content sequence (07)
The Boil-Marriott law states the relation between volume and pressure changes in gas at a fixed level of temperature. The volume of a certain amount of gas (V) has reversed relation with its pressure (P) at a fixed level of temperature. So, the formula is this.”
Teacher writes on the blackboard: \( V \propto \frac{1}{P} \), or \( V = \text{fix value} \times \frac{1}{P} \) or \( PV = \text{fix value} \).

Teacher asks students to solve two related problems.

Teacher continues: “The third law for gas suggest that the pressure of a certain amount of gas (P) has direct relation with its absolute temperature (T) provided a fixed value of volume. So, the formula is this.”

Teacher writes on the blackboard: \( P \propto T \), or \( P = \text{fix value} \times T \) or \( \frac{P}{T} = \text{fix value} \).

Teacher asks students to solve a related problem.

**Content sequence (08)**

Teacher explains: “in all gas laws which were discussed so far, the value of one of these quantities; i.e., P, V, and T was assumed to be fixed. Now, we consider a situation within which all three quantities could be changed. In this case, we can find out the relationship between P, V, and T by the help of previous laws, which have been stated for specific conditions. This relationship is called gas status equation.”

Teacher continues to explain while writes on the blackboard: “Suppose we have certain mass of air at pressure level of \( P_1 \), volume of \( V_1 \), and temperature of \( T_1 \). First we increase its temperature to \( T_2 \), while keep its pressure fixed, so the gas volume will be \( V \) we can calculate the \( V \) through Charles – Giulsick formula: \( \frac{V}{V_1} = \frac{T_2}{T_1} \). Then we increase its pressure to \( P_2 \) while keep its temperature fixed, so the gas volume will be \( V_2 \) we can calculate the \( V_2 \) through Boil-Marriott formula: \( \frac{V_2}{V} = \frac{P_1}{P_2} \). You can consider the following relations now.”

Teachers continues to write: \( \frac{V'}{V} \times \frac{V_2}{V} = \frac{T_2}{T_1} \times \frac{P_1}{P_2} \) or \( \frac{V_2}{V_1} \times \frac{T_1}{T_2} = \frac{P_1}{P_2} \) or \( \frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \) or finally we can say \( \frac{PV}{T} \), which is the gas status equation.

Teacher says: “You have to keep in mind some conditions regarding gas status equation. First, the mass of gas must be fixed temperature degrees \( T_1 \) and \( T_2 \) must be measured on Kelvin scale. Third, the units of V and P must be same on two sides of equation.”

Teacher asks students to solve a related problem.

**Formative evaluation**

Teacher asks students to solve one or two related problems at the end of each section.

**Home assignment**

Solve the problems, which have been given at the end of the chapter.
Lesson No. 5

Topic: electrostatic

Instructional objectives:
After the instruction is over, students will be able to:

1. define the electric charge.
2. explain the various electric charges.
3. name the ways of getting electric charge.
4. explain the electric charge distribution on the surface of conductor.

Prerequisite knowledge of students:
It is assumed that students are aware of structure of molecules and atoms, and some concepts like area, surface, density, and distribution.

Instructional aids:
In addition to chalk and blackboard, some ebonite strips, glass lamellas, and threads are needed for doing the experiment concerning the various electric charges. A large size diagram showing the mechanism of charging by induction (which its small size has been given in textbook) is also needed.

Content sequence:
1. Electric charge.
2. Various electric charges
3. Ways of getting electric charge
4. Electric charge distribution on the surface of conductor

Instructional program:

Content sequence (01)
Teacher tells the students: "we learn today something about electrostatic."
Teacher asks: "If you rub two objects against each other, what will happen?"
Students answer the teacher.
Teacher confirms or corrects.
Teacher says: "It is said that rubbing produces heat and erodes the surface of materials. The other effect of rubbing is creation of attraction between rubbed surfaces. You have seen, for example, that after a plastic comb is rubbed against a piece of cloth, it can attract dust, hair or small pieces of paper. It seems that something invisible has been created on the surface of comb. This is the electric charge."
Content sequence (02)
Teacher asks students to do the following experiment.
Teacher says: “Give electric charge to an ebonite strip and glass lamella separately through rubbing. Then hang them down by help of dry threads from their centers of gravity. Then give electric charge to an additional ebonite strip and glass lamella through same method. Now bring first the glass lamella close to the hanging objects and see what is happened. At second time, bring the ebonite strip close to the hanging objects and see what is happened.”
Teacher asks students: “Can you explain your observations?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: “As you saw, two glass lamellas or two ebonite strips repel each other, but an ebonite strip and a glass lamella attract each other.”
Teacher concludes: “The force that charged objects impose on each other is called electric force. Two types of charge are produced. The produced charge on ebonite (or polytonal) and similar charges are negative charges. The produced charge on glass lamella (or stat cellules) and similar charges are positive charges. There has been not found any object till now that can repel positive and negative charges both. Therefore we can understand now the basic law of electrostatic, which is as follow; like charges repel each other and unlike charges attract each other.”
Teacher explains: “You have to take atom’s structure into account to justify how objects get electric charge. As you know three important particles, i.e., electron, proton, and neutron are main components of atoms. Protons, and neutron compose the atom’s nucleus and electrons rotate around the atom’s nucleus. Electrons have negative charge, which is inseparable from them. Proton’s charge is positive and its amount is same as electron charge. Because of this fact, atoms, which usually have equal number of protons and electrons, are neutral. The third existed particle in atom, i.e., neutron is uncharged.”

Content sequence (03)
Teacher continues: “Now, we can explain what happens when rubbing is occurred between two materials. The electrons, which are connected loosely to the atoms of surface of an object become detached and sit down on the surface of other object during rubbing process. The object, which receives additional electrons, gets negative electric charge and the object, which looses some of its electrons, gets positive electric charge.”
Teacher concludes: “The smallest independent charge which could be existed is the charge of an electron or charge of a proton. We show the size of electron or proton’s charge with the symbol “e” and we call it as “elementary charge”. The electron’s charge is showed with “−e” and proton’s charge with “+e”. The electric charge that is produced in an object through acquiring or loosing some electrons (for example n electron) is 227
shown with “q”. This (q) is always a multiple of elementary charge (e). So we can say q=ne.” Neither any charge is created nor lost in rubbing process but it is transferred from an object to another. This transition is a result of electron transfer.”

Teacher says: “The electric charge remains static on some materials and can not move through them or on their surfaces. These kinds of materials are nonconductors. You learned something about charging by rubbing. Another way of producing electric charge is charging by contact. If we make contact between two nonconductors, one with electric charge (A) and the other without it (B), the charge will stays on A and will not be transferred to B, unless they will be rubbed against each other; but if we make contact between two conductors, one with electric charge (C) and the other without it (D), the charge will be distributed on the surface of both conductors. Conductors share their electric charge in contact with each other.”

Teacher continues: “There is a third way of charging which is called charging by induction. You can understand this process by looking at this diagram, which shows how the induction process begins from an inductor and continues towards two conductors. Producing charge in conductors without any contact between them is called charging by induction.”

Content sequence (04)
Teacher explains: “Surface density of charge is defined as value of charge per unit of conductor’s surface. Wherever the surface has sharper curvature, surface density of charge is greater than that of its other areas. The charge is distributed equally on the surface of a spherical conductor, but the surface density of charge is greater on the peak of pear shape or conic conductor than its other areas.”

Teacher tells students: “Note that this explanation is just right in case of surface of conductors. It is not applicable absolutely in case of nonconductors.”

Teacher asks students: “Do you know why?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher continues: “There is not any charge on the internal surface of an empty spherical conductor which has not any way to outside. And the whole given charges are distributed on its outer surface.”

Formative evaluation
(1) Explain how objects are charged.
(2) Name the ways of charging.
(3) Explain the difference between charging by contact and charging by induction.
(4) Explain why the electric charge is not distributed on the surface of nonconductors.

Home assignment
Try to find out conductors and nonconductors in your life setting.
Lesson No. 6

Topic: electrostatic

Instructional objectives:
After the instruction is over, students will be able to:

(1) explain the relationship between distance, charge amount and electric force.
(2) explain the electric field.
(3) explain the electric field of a point charge.
(4) explain the electric potential difference.

Prerequisite knowledge of students:
It is assumed that students are aware of mechanism of electric charging and its different ways and some concepts like electric force, distance, density, gravity, distribution and conservation of energy.

Instructional aids:
In addition to chalk and blackboard, some metal balls, some pieces of silk threads, and charge generator for doing the experiment concerning the Colon law for electric force. A large size diagram for electric field is also needed.

Content sequence:

(1) Distance, charge amount and electric force.
(2) Electric field.
(3) Explain the electric field of a point charge.
(4) Explain the electric potential difference.

Content sequence (01)
Teacher says: “As you learnt in previous lesson, charged objects can affect each other without any contact. This effect from a distant point can be explained through electric field, but first we must identify the factors affecting greatness of electric force. By help of an experiment, you can specify the relationship of the distance of two charged objects and their charge size with the electric force between them.”
Teacher asks students to do the following experiment.
Teacher says: “Hang the charged metal ball B down by help of a piece of nonconductor thread (like silk). Bring the second charged ball A that has been fixed to a nonconductor handle, so that the like charges cause the diversion of ball B. The amount of this diversion, like the diversion of electroscope’s sheet, is an index of the greatness of imposed force on this ball. More diversion is a sign of existence of stronger repelling force.”
Teacher asks students to give electric charge to the both of balls by the help of a charge generator.

Teacher says: "As you see, the ball B is diverted from its vertical status. The experiment shows that electric force is increased by remoteness decline. This is a reverse relationship. The precise measurements show that the imposed electric (repelling) force on each charged objects has reverse relation with the square of remoteness between them. So we can write the following formula."

Teacher writes on the blackboard: \( F \propto \frac{1}{r^2} \) or \( F \propto \frac{1}{\text{square of distance}} \).

Teacher says: "The imposed electric (repelling) force on each charged objects has direct relation with the size of their charge. So we can write the following formula."

Teacher writes on the blackboard: electric force \( \propto \text{product of charges} \) i.e. \( F \propto q_A \cdot q_B \).

Teacher continues: "These relations were discovered for the first time in 1785 by Colon and are known as Colon law. We can conclude accordingly that the greatness of electric force that two charged molecules having \( q_1 \) and \( q_2 \) charges, impose on each other in remoteness of \( r \) is calculated through the following formula."

Teacher writes on the blackboard: \( F = k \frac{q_1 q_2}{r^2} \).

Teacher says: "The \( k \) coefficient is dependent on the selected units system. In international standard units that \( q_1 \) and \( q_2 \) are measured in terms of Colon(C), \( r \) in terms of meter (m) and \( F \) in terms of Newton (N), the value of \( k \) is as follow."

Teacher writes on the blackboard: \( k = 9 \times 10^9 \text{ N.m}^2 \text{C}^2 \).

Teacher asks students to solve a related problem.

**Content sequence (02)**

Teacher explains: "As you know the earth has gravity field. The effect of this field is observed in the form of gravity force (weight force), which is imposed on the existing objects in this field. There is also an electric field around a charged object, which its effect is observed in form of electric force that imposed on existing charges in that field. This effect, which is existed around each charged object, is called electric field. Since the electric field imposes the force on the existing charges in the field, we can conclude that electric field has vector nature and thus has greatness and direction."

Teacher explains: "The electric field direction at each point is identical with the direction of the force which is imposed on charged object by the field itself at that point. Therefore the direction of the force imposed on an
object having negative charge is against the direction of the field that has caused this force. You can understand this explanation through looking at the diagram.”

Teacher continues: “The imposed force on the unit of positive electric charge at each point of electric field is called electric field intensity. It is shown with E and calculated through this formula: $E = F/q_0$.

Teacher explains: “The unit for electric field intensity is Newton per Coulomb. Since the charge $q_0$ itself also produces electric field, E can be an index for intensity of field of charges other than $q_0$ at point A, if $q_0$ would be extremely small.”

**Content sequence (03)**

Teacher asks students to look at the following figure.

![Diagram](image)

Teacher explains while drawing the figure and writing the formulas on the blackboard: “Consider the point charge $+q$. If small positive charge $q_0$ falls at point A by remoteness of $r$ from $q$, a force equal to $F = k \frac{qq_0}{r^2}$ is imposed on it from the field of charge $q$. The greatness of electric field of charge $q$ at point A is calculated through $E = F/q_0$ according to the given definition.

So we have $E = \frac{kqq_0}{r^2} \rightarrow E = k \frac{q}{r^2}$.”

Teacher says: “This relation shows that intensity greatness of electric field of point charge $q$ at every point is proportionate to charge amount of $q$ and has reverse relation with square of remoteness of intended point from charge $q$. Note that the field intensity of charge $q$ is independent from field intensity of charge $q_0$ and is not same at different points of sphere. If the direction and intensity of field are fixed in a portion of sphere, the field is called uniformed field. Two conductor plates, one with positive and the other with same amount of charge, but negative, must be placed parallel and close to each other to create uniformed field.”

Teacher asks students to solve a related problem.

**Content sequence (04)**

Teacher asks student: “Do you remember the meaning of conservation of energy which has been taught last year?”

Students answer the teacher.

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Teacher confirms or corrects.
Teacher says: “This concept is helpful for solving mechanic problems. This concept is also useful for solving problems of electricity. It is better in many cases to use the concept of energy instead of force and electric field.”
Teacher explains: “Look at the figure in your textbook. If we want to pull up slowly an object with the mass of m, by fixed speed, from point A at gravity field of ground to point B by height h, we must do work equal to mgh. The work which is done (mgh) is saved in form of upsurge of gravitate potential energy.”
Teacher continues: “If we want to move the charge +q in electric field against the field direction, by fixed speed, from point A to point B, we must impose a force on it from outside, so we must do a positive work. This work is saved in form of potential electric energy. If charge goes back from B to A, this energy will be freed. If q=+1 colon in this displacement, the done work is called electric potential difference or voltage between two points. The electric potential difference between two points A and B (V_B - V_A) is equal to the work, which has been done to displace a unit of positive charge from A to B. now we have this formula.”

Teacher writes on the blackboard: \[ V_{BA} = V_b - V_A = \frac{W}{q} \]

note that \( V_{BA} = V_A - V_B = -V_{BA} \), potential difference unit is joule over colon, which is called volt, \( 1V = 1\frac{J}{C} \).”

Teacher says: “Note that electric potential difference between two points is not related to the size of displaced charge. So far, we defined the electric potential difference between two points.”
Teacher asks student: “Could you calculate the electric potential difference of every points in relation to a given point like A?”
Teacher guides students to find the way step by step to conclude this formula \[ E = \frac{F}{q} \rightarrow E = \frac{V}{d} \] (d=distance).

Teacher asks students to solve a related problem.

**Formative evaluation**
Formative evaluation takes place by solving one or two problems after each section is taught.

**Home assignment**
Solve the problems, which have been given at the end of the chapter.
Lesson No. 7

Topic: electric currents

Instructional objectives:
After the instruction is over, students will be able to:
(1) define the electric circuit.
(2) explain the flow of the electric charge.
(3) explain the flow of charge and electric current.
(4) explain the mechanism of electric conduction in metals.
(5) explain how could the electric intensity be measured.

Prerequisite knowledge of students:
It is assumed that students are aware of mechanism of electric charging, the different ways of charging and chemical structure of atom. They must also know some concepts like electric force, conduction, conductor, semiconductor, nonconductor, charge distribution, conservation of energy, electric field, electric potential difference,

Instructional aids:
In addition to chalk and blackboard, a large size table showing symbols for electric circuit components is also needed.

Content sequence:
(1) Electric circuit.
(2) Flow of the electric charge.
(3) Flow of charge and electric current.
(4) Mechanism of electric conduction in metals.
(5) Measurement of electric intensity.

Instructional program:

Content sequence (01)
Teacher says: “We learn today something about the electric current. As you have learnt already electric charge causes repelling and attraction between charged objects. It flows also in conductors. Its flow produces electric current. If electric current is to be continued, the electric charge needs a closed path to flow in. The path that charges pass through is called electric circuit.”

Content sequence (02)
Teacher explains: “We can see how electric charge flows in a circuit with the help of an excrement which has been explained in your textbook. Design of this experiment in your textbook shows that static electric charge
and the charge, which flows in electric current both have same origin, that is, electron. The potential difference between two points (M and N) produces the charge flow in circuit. If the charge flow is to be made permanent in circuit, the generator must maintain a fixed potential difference between two ends of circuit, i.e. points M and N. Battery, dynamo, generator and solar cell are devices, which can create potential difference between two ends of circuit. Generator gives energy to electric charges to enables them to flow in circuit. The given energy to a unit of electric charge (col) by generator, to enable it to flow in circuit, is called electric motive power of generator. The unit of electric motive power is volt.

Content sequence (03)

Teacher explains: “Only free electrons or as they are called conduction electron could be displaced in metal objects, whereas in liquids and gases, free electrons and positive and negative ions could be displaced. When a potential difference is given to a tube containing gas, like tube light, positive and negative charges move inside the tube. Positive charges move from high potential point to low potential point, i.e. they flow in circuit from positive pole to negative pole of generator, whereas negative charges flow in reverse direction, i.e. from low potential point to high potential point. As I said this takes place in case of gas, but in case of metal conductor, only conduction electron flow just from low potential point to high potential point.”

Teacher continues: “When potential difference is not given to two ends of a conductor and it is not in the circuit, free charges move randomly inside the conductor, so that net displaced charges from a cross section of conductor within each span of time is equal to 0, that is, if charge electric \( \Delta q \) passes from one cross section of conductor and from left to right, within time span of \( \Delta T \), another electric charge equal to \( \Delta T \) passes from the same cross section and within same time span but from right to left. Although in this case, electric charges are displaced, no any net electric charge has flowed from cross section of conductor. Hence we say there is not any current in conductor. It is just like water inside a pool or air inside a room that its doors and windows are closed. There is not any air current despite of random motion of air molecules. When a potential difference is given to two ends of a conductor, all existing free charges inside the conductor start to move almost simultaneously. They also move randomly and if they are positive charges, they move from high potential difference to low potential difference, otherwise they move in opposite direction. In this case net flowed charges from any cross section of circuit is not equal to 0. Hence we say current is set on in the circuit.”

Teacher says: “We have to make circuit to study the electric current. We need a simple method and some symbols for components of a circuit to...”
show the circuit. You can see some of them in this table. This table is also
given in your textbook.”

**Content sequence (04)**
Teacher explains: “electric conduction in metals is pertain to free electrons.
Free electrons are vagrant at random in metal. When two poles of battery
are connected to two ends of a metal, an electric field is established inside
the metal. Free electrons accelerate under the effect of field and their speed
and energy is increased subsequently. These electrons give some of their
energy to an atom, which is oscillating, around an average fixed position,
during the encounter with this atom. Thus the oscillating scopes of atoms
are increased and the temperature of metal will be increased. Free electrons
accelerate again under the effect of electric field and loose some of their
energy again. Although their motion is irregular, but on the average,
electrons are impelled to move with an average speed in the direction of
field and make the electric current.”

**Content sequence (05)**
Teacher says: “The intensity of passing current in circuit must be relevant
to components of circuit. Low intensive current, for example, may not be
able to turn the light on, while high intensive current may burn the light
out. Therefore measurement of electric current in circuit is important.”
Teacher explains: “electric charges must flow in order to produce electric
current. If the electric charge $\Delta q$ within time $\Delta t$ flows from a cross section
of circuit, according to the definition, this ratio $\frac{\Delta q}{\Delta t}$, that is, flowed
charge per time unit is called average electric current intensity. It should
not be mistaken by average speed of flowed charges. While average speed
of charges within time $\Delta t$ is equal to the size of displacement of charges per
time unit, the electric current intensity is defined as flowed charge per time
unit. As much as we select the $\Delta t$ smaller, average electric current
intensity would be closer to momentarily current intensity at each point.
Thus, electric current intensity is rate of flow of charge in circuit. A fixed
electric current intensity will be established in circuit, if a fixed potential
difference is connected to two ends of circuit. In this case, if flowed charge
from each cross section of circuit within time $t$ would be equal to $q$, the
electric current intensity is calculated through this formula: $I = \frac{q}{t}$. The
electric current intensity is a main quantity and its unit is ampere (A).

**Formative evaluation**
Teacher asks students to answer the questions, which has been given in the
end of chapter in their textbook.

**Home assignment**
Solve the problems, which has been given in the end of chapter.
Lesson No. 8

Topic: electric currents

Instructional objectives:
After the instruction is over, students will be able to:
(1) Explain the parallel and series connection.
(2) Explain the potential difference in parallel and series circuits.
(3) Explain the electric resistance and Ohm law.
(4) Calculate equivalent resistance in parallel and series circuit.
(5) Explain the resistance and rheostat.
(6) Explain the relation between potential difference and intensity of electric current in generator.
(7) Explain the heat effect of electric current.

Prerequisite knowledge of students:
It is assumed that students are aware of mechanism of electric circuit, flow of the electric charge, electric conduction, and measurement of electric intensity

Instructional aids:
Chalk, blackboard and textbooks are needed.

Content sequence:
(1) Parallel and series connections.
(2) Potential difference in parallel and series circuits.
(3) Electric resistance and Ohm law.
(4) Equivalent resistance in parallel and series circuits.
(5) Resistance and rheostat.
(6) Relation between potential difference and intensity of electric current in generator.
(7) Heat effect of electric current.

Instructional program:

Content sequence (01)
Teacher explains: “Conductors could be connected to each other in different forms, but these forms of connection are usually combinations of two main ways of conductor connection, which are called parallel and series connections. You can see some of these connections shown in figures of your textbook.”
Teacher continues: “Circuit current is divided in parallel connection and only a portion of current flows in every conductor. If some lamps have paralleled connection, when a lamp is set off or is burnt out, other lamps
will remain on. This is the most usual way of light connection. The imposed intensity of current on a junction or tie \((J,J')\) in circuit is equal to the sum of intensity of outgoing currents from the same junction.”

**Content sequence (02)**
Teacher says: “Voltmeter measures the potential difference (or voltage) in terms of volt. Voltmeter readings show that \(V_1+V_2+V_3=V_T\). The sum of voltages of two ends of each lamp in a series connection is equal to voltage of whole two ends of all lamps. So we can conclude that voltage of two ends of conductors, which connected serially are summed up with each other. Voltmeter readings show that \(V_B\) (potential difference of two ends of electric cell) is equal with the potential difference of two ends of each lamp \((V_C)\) in a parallel connection. Therefore we can say that always potential difference or voltage of two ends of conductors are same in a parallel connection.”

**Content sequence (03)**
Teacher asks student: “Could you tell us some instances of resistance in daily life? What do you know about the reason of these resistances?”
Students answer the teacher.
Teacher confirms or corrects.
Teacher explains: “Since we need a battery or generator to make electric current to flow, there should be some resistance against the current flow in conductor. As you have learnt already, generator gives energy to free electrons in a circuit to make them flowing, but these electrons loose some of their energy during the encounter with the atoms inside the conductor, that is, a conductor resist against the current flow. Lost energy inside the conductor by electrons, causes the upsurge of temperature of conductor. Electric resistance is dependent on these factors: (a) size and shape of conductor, (b) material of conductor, and (c) temperature of conductor.”
Teacher says: “Conductor resistance opposes to flow of current in the circuit. So the current intensity must be measured in order to study the conductor resistance. The voltage, which produces the current in the conductor, must also be measured. The relationship between current intensity \((I)\) and potential difference or voltage \((V)\) is essence of the definition of electric resistance. Resistance of a conductor is equal to ratio of voltage of its two ends and voltage of the current, which flows through it. So we can write the relationship as follow.”
Teacher writes on the blackboard: \[ R = \frac{\text{voltage of two ends of conductor}}{\text{intensity of flowing current}} \] or \[ R = \frac{V}{I}. \] Since intensity is measured in terms of ampere, the electric resistance unit is \(\frac{V}{A}\), which is called ohm. It is shown by the symbol \(\Omega\).
Teacher explains: “One ohm is resistance of a conductor when a current with intensity of one ampere passes through it, while the voltage of its two ends is one volt. Resistance is changed in almost all conductors following the change in temperature. The resistance of metal conductors is increased following the upsurge of temperature. Temperature upsurge in semiconductors reduces their resistance. So resistance value is fixed till temperature degree is fixed. So now we can conclude the ohm law. It says that the current intensity passing through a metal conductor at a fixed level of temperature is proportionate with potential difference (voltage) of its two ends. That is, $I \propto \frac{V}{I}$ for a conductor remains fixed at a fixed level of temperature, it is said that this conductor follows the ohm law. This conductor is called ohm conductor (resistor). ”

**Content sequence (04)**

Teacher explains: “Resistance of whole circuit, in case of series connection, must be obtained in order to calculate current intensity of circuit. As you have learnt voltage of two ends of circuit, in case of series connection is equal to sum of potential differences of its all components with each other and the intensity of current which passes through serial resistor is same. If voltage $V$ would be connected to two ends of one resistor instead of two ends of all serial resistors and the same current, which passes through them, passes through this single resistor, this resistor is equivalent to all those resistance, which connected in series. So we can conclude following relations.”

Teacher writes on the blackboard: $V=V_1+V_2+V_3$. So we can apply $V=IR$, for each resistor. So $V=IR_1+IR_2+IR_3$ or $V=I (R_1+R_2+R_3)$. Then we can apply $V=IR$ for equivalent resistor. Since $V$ and $I$ are same in both formulas and by comparison of these formulas, we have $R=R_1+R_2+R_3$.

Teacher asks students: “How about the resistors in parallel connections? Could you explain it based on whatever you have learnt till this moment?”

Teacher asks one of students to come and explain the matter and helps him/her to conclude the relations and write the related formulas on the blackboard.

**Content sequence (05)**

Teacher says: “When an electric circuit is switched off, the assurance should be obtained prior to reconnection that reestablishing the current does not cause damage to components of circuit. So, in order to protect the circuit and its components a variable resistor is placed in circuit, which is called rheostat.

**Content sequence (06)**

Teacher says: “As you know, the used energy by generator to enable a unit of electric charge (colon) to flow in circuit is called electric motive power
of generator (E). Its nature is of potential difference. The unit of electric motive power is volt.”

Teacher explains: “If we reduce the resistance of circuit by help of a rheostat, ammeter shows higher intensity of current and voltmeter shows smaller number, which means the potential difference of two ends of generator is decreased against the upsurge of intensity.”

Teacher asks student: “Do you know why?”

Students answer the teacher.

Teacher confirms or corrects.

Teacher says: “This resistance of generator is called internal resistance (r). Since intense of main current passes through generator, it causes the waste of energy. Wasted energy against the passage of a unit of charge is called potential failure of generator. If intensity of circuit current is I, potential failure of generator is Ir. Subsequently, potential difference of two ends of generator terminal (V) is equal to E—Ir.”

Teacher writes on the blackboard: potential difference of two ends of resistor (R) is equal to potential difference two ends of generator. Therefore we can write V=IR. So we can conclude the following equation from these two relation, i.e. E—Ir=IR. Finally we can write E=I(r + R) or I = \frac{E}{R + r}.

Teacher asks students to solve two related problems.

**Content sequence (07)**

Teacher says: “As you have learnt already, current flow in a conductor, increases the temperature of conductor.”

Teacher writes related formulas on the blackboard while explains:

“According to definition, potential difference (V = \frac{W}{q}) of needed energy to enable the charge q to flow in a conductor can be calculated as W=Vq. The potential difference of two ends of a conductor with resistance value of R, when a current with intensity of I passes through it, is V=IR. Flowed charge in conductor within time span of t is calculated as q=It. So finally we can write: W=Vq=RI (It) or W=RI^2t.”

Teacher says: “The heat energy resulting from electric current in a conductor is proportionate with following factors: (a) current intensity square; I^2, (b) electric resistance of conductor; R, and (3) time span of current flow in conductor; t.”

Teacher writes on the blackboard: write above said relations in form of this formula, W = Vq = \frac{V^2}{R} t = VI t .

Teacher asks students to solve two related problems.

Teacher continues to explain: “As you know, the power of an electric heater is more than power of a lamp, because it can convert more electric
energy in a specific span of time to heat or radiation energy. Actually the power is rate of energy conversion.”

Teacher writes on the blackboard: So we can write,$$
\text{power} = \frac{\text{converted energy}}{\text{time span}}. \text{ So we have } P = \frac{W}{t}.
$$

Teacher asks students to solve two related problems.

**Formative evaluation**

Formative evaluation takes place by solving one or two problems after each section is taught.

**Home assignment**

Solve the problems, which have been given at the end of the chapter.
Scale of Attitude Towards instructional Media

Dear student;

This is a study of attitude towards instructional media. In the following pages, you will find a number of statements followed by different degrees of agreement, ranging from strongly agree with the statement on one end to the strongly disagree on the other end.

Please check the degree of agreement (abbreviated in columns: SA=Strongly Agree, A=Agree, U=Undecided, DA=Disagree, SDA=Strongly Disagree) by putting a tick mark on that column which you consider as correct for the statement, your information will be used for the purpose of research only.

Name: ______________________ class: ____________ school: ____________

<table>
<thead>
<tr>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>U</th>
<th>DA</th>
<th>SDA</th>
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<tbody>
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<td>2. Libraries are essential for developing reading habits in pupils.</td>
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<td>3. School libraries play an important role in students' growth.</td>
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<td>4. Teachers' facial expressions have similar effects on all students.</td>
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<td>5. Maps and globes are difficult to follow.</td>
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<td>6. Guidance by the teacher stimulates students to work hard for the success.</td>
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<td>7. Group discussions are essential for generating new ideas.</td>
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<td>8. TV and Radio are equally effective.</td>
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<td>9. Educational tours are essential for providing long range learning experience.</td>
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<td>10. Students are more attentive when taught through computers.</td>
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<td>11. Learning can be made more successful by teaching individually rather in-group.</td>
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<tr>
<td></td>
<td>Attitude scale</td>
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<td>---------------</td>
<td></td>
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</tr>
<tr>
<td>12.</td>
<td>Computers are equally effective for arts and science students.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>13.</td>
<td>TV is superior to printed materials.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>14.</td>
<td>OHP transparencies do not raise the quality of instruction.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15.</td>
<td>Computers are the status symbols of schools.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Computers are not used in teaching.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>17.</td>
<td>Charts do not help the students to understand topics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Praise is essential for effective learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Question-answering technique is essential for involvement in teaching-learning process.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Teachers do not give importance to explanation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Pictures do not make chapter alive.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Models do not give originality to the subject matter.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Computers make the teaching interesting.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Illustrations add to the clarity of the subject matter of topics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>Explanation given by teacher is better than that of books.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>TV Broadcasts have the potential to meet more effectively the changing needs of our society.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dear student,

This is a self-administering questionnaire. It has been developed for fulfillment of research purpose. So please answer the questions carefully regarding your father (or regarding your guardian, if your father is not alive). You have to choose only one answer and to put a check (✓) against that answer.

1. What kind of occupation/profession your father is engaged?
   A. High administrative (gazette officer); Managerial or business; High profession, (big Lawyer, Doctor, University Professor)
   B. Average administrative (non gazette officer); business and technical jobs; Professionals such as average Lawyer, Doctor, College teacher, Merchants.
   C. Clerk or Trader; Ordinary business or technical work, or other skilled jobs, Middle or primary school teacher.
   D. Semi-skilled jobs; Agricultural job; Artisan or ordinary employee in government service.
   E. Unskilled laborer; any other manual work

2. What is your father’s highest level of education?
   A. Research or Doctorate degree
   B. Postgraduate degree
   C. Graduate degree
   D. Intermediate
   E. High school diploma
   F. Middle school education
   G. Primary school education
   H. Illiterate

3. What is your average monthly income?
   A. More than two million Rials
   B. Between 1.5 million to two million Rials
   C. Between one to 1.5 million Rials
   D. Within half million and one million Rials
   E. Up to half million Rials

4. What type of house do you live in?
   A. A big villa type house
   B. A small villa type house
   C. A big flat
   D. A small flat
   E. A single room

5. How much your family spends in a month on magazines/books, etc.?
   A. More than ten thousand Rials per month approximately.
   B. Between six to ten thousand Rials per month approximately
   C. Within four to six thousand Rials per month approximately
   D. Within two to four thousand Rials per month approximately

243
6. Does a newspaper come to your house regularly?
   A. Yes
   B. Sometimes
   C. Never

7. What is the highest education your brother/s has obtained/is obtaining?
   A. Postgraduate or above
   B. Up to graduate
   C. Intermediate
   D. Matriculation or higher secondary

8. What is the highest education your sister/s has obtained/is obtaining?
   A. Postgraduate or above
   B. Up to graduate
   C. Intermediate
   D. Matriculation or higher secondary

9. What kind of occupation do you like to settle your economic life or what is the most desirable profession you have planned/ would plan?
   A. Engineer, doctor, professor, executive jobs
   B. Social worker, artist, trader
   C. Mechanic, clerk, accountant, salesman, teacher

10. Which of the followings should determine a person's social prestige?
    A. His occupation/profession/job
    B. His economic status, poverty, etc
    C. His academic qualifications
MAJUMDAR SCIENTIFIC CREATIVITY TEST

Part I
1982

General Instruction

This is a test for creative thinking in Science. The tests often demand novel and unconventional responses.

Each of the subtests has a definite time limit, which is to be strictly observed. You are to start and stop working on it, as and when you are asked to do so.

Each subtest will be explained to you before you are asked to start working on it; put any question that you have, at that time. Once you are instructed to start working, there will be no extension at time limit, even though explaining is done.

Try to solve as many problems as you can and do not be sorry for not being able to answer all these being from different areas, may not all be solved by any one person.

Be fluent and try to give as many different novel responses as you can, where such is the requirement.

Take everything in right spirit.

Hope, you will find it interesting.

Please do not turn over a page until you are asked to do so.

Published by
MANASAYAN
32, NETAJI SUBHASH MARG
NEW DELHI - 110002
M.S.C. Test No. 1: PIN ARRANGEMENT

**Instruction:** Below are triangles each made of 12 pins. Now, with 5 additional pins, construct – maintaining parallelism with the sides – the following:

**Example:** 4 triangles inside another triangle –

within the given triangle (the solution is demonstrated here with dotted lines):

![Example Diagram]

**Note:** Use all the five pins in each solution. Each pin must be placed parallel to one of the sides of the given triangle.

**Problems:**
(a) 4 triangles (whose sides are not common)–within the given triangle
(b) 1 triangle inside another triangle–within the given triangle.
(c) 3 triangles (whose sides are not common)–within the given triangle.
(d) 2 triangle (whose sides are not common)–within the given triangle.

**Time limit: 5 minutes.**

**Solutions:**

(a)  
(b)  
(c)  
(d)  

(Use the triangles on the next page for additional solutions)
M.S.C. Test No. 1: PIN ARRANGEMENT

Give below as many additional novel solutions to the problems as you can.
(Mark the problem No. against each response):

(More such triangles are provided on the back cover of this booklet for further additional responses, if any).

Please do not turn over the page until you are instructed to do so.
M.S.C. Test No. 2: LIKENESS

Instruction: State five similarities between the two:

a) Chlorine and iodine.
b) Light and radio waves.
c) Plants and animals.

Time limit: 3 minutes.

Answers:

a) 1. ........................
    2. ........................
    3. ........................
    4. ........................
    5. ........................

b) 1. ........................
    2. ........................
    3. ........................
    4. ........................
    5. ........................

c) 1. ........................
    2. ........................
    3. ........................
    4. ........................
    5. ........................

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 3: PORT DISTANCES

Instruction: A, B, C, D, E, F, G, H, I, J, K, and L are ports along the coast— the distance between consecutive ports is 5 miles. You are to find out the distances of ships in the sea, from their ports of call.

Example: Ship P from port F 

Answer: 18.02 miles.

Problems: (a) Ship Q from port C 
(b) Ship R from port B

Answer: (a) 
(b)

Time limit: 4 minutes.

[Space for Calculation]

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 4: **COMBINATIONS**

**Instruction:** Combine two given objects in various ways to make five different objects.

**Objects given:**

<table>
<thead>
<tr>
<th></th>
<th>Answers (Objects made)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Pencil and thread</td>
<td>1.</td>
</tr>
<tr>
<td></td>
<td>2.</td>
</tr>
<tr>
<td></td>
<td>3.</td>
</tr>
<tr>
<td></td>
<td>4.</td>
</tr>
<tr>
<td></td>
<td>5.</td>
</tr>
</tbody>
</table>

b) Cork and needle

<table>
<thead>
<tr>
<th></th>
<th>Answers (Objects made)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
</tbody>
</table>

**Time limit:** 2½ minutes.

Do not go onto the next test until you are asked to do so.

M.S.C. Test No. 5: **NUMBER ATTRIBUTES**

**Instruction:** find out numbers that are all—

i. Multiples of some odd numbers
ii. Divisible by four
iii. End in zero, and
iv. Factorial of a number

**Answers:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.......</td>
</tr>
<tr>
<td>2.</td>
<td>.......</td>
</tr>
<tr>
<td>3.</td>
<td>.......</td>
</tr>
<tr>
<td>4.</td>
<td>.......</td>
</tr>
<tr>
<td>5.</td>
<td>.......</td>
</tr>
</tbody>
</table>

**Time limit:** 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 6: CORRECT LOCATION

(a) LOCATING THE TANGENT

**Instruction:** State which of the straight lines – AB, CD, EF, and GH – will just touch the circle at one point to form a tangent.

![Diagram of a circle with lines AB, CD, EF, and GH]

**Answer:**

Time limit: 1 minute.

Do not go onto the next test until you are asked to do so.

(b) LOCATING POINT ON THE CIRCUMFERENCE

**Instruction:** Select a point that will fall on the circumference of the circle.

![Diagram of a circle with points P, Q, R, S, and T]

**Answer:**

Time limit: 1 minute.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 6 (Continued):

(c) LOCATING ELECTRONIC SWITCH

Instruction: A, B, C, D, and E are switches connected to batteries. Indicate which of these switches will light up the lamp L.

- Dots indicate that the crossing wires are connected at those points. Ω these symbols indicate that the wires are not connected at the crossing points.

Answer:

Time limit: 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 7: IDENTIFYING FIGURES

Geometric figures:

Instruction: Find out which of the above geometric figures, of the same size and shape, and how many of each, can be seen in the following pictures:

(a) Chair  (b) Box  (c) Cot

Answers: (a) (b) (c)

Time limit: 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 8: MULTIPLE USES

Instruction: List the various uses of the following:

Problems: Answers:

(a) Barometer (a) ..............................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................

(b) Saw dust (b) ..............................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................
........................................................................

Time limit: 2½ minutes.

Do not go onto the next test until you are asked to do so.

M.S.C. Test No. 9: DEDUCTION

"Some particular enzymes act as catalyst in some particular organic reactions."

Instruction: Choose one of the following conclusions that follow from the above statement.

A. All catalysts are enzymes.
B. Enzymes are organic catalysts
C. Enzymes act as catalysts in all organic reactions.
D. Some enzymes have no catalytic action.
E. Some inorganic reaction is helped by some enzymes.

Answer:

Time limit: 1½ minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 10: PERFORATION

Instruction: Indicate with circles where perforations will come out in an unfolded paper (as shown on the right), after it has been folded and punched (as shown on the left)

Problems: (Folded and punched)  

(a) [Diagram of folded and punched paper]

(b) [Diagram of folded and punched paper]

Answers: (Unfolded)

(a) [Diagram of unfolded paper]

(b) [Diagram of unfolded paper]

Time limit: 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 11: ANALOGIES

**Instruction:** Complete the following analogy from each of the two lists:

Photovoltaic cell: light: chlorophyll?

(a) A. Oxygen B. Carbon dioxide C. Sugar D. Water
(b) A. Chemical energy B. Sun’s ray C. Green color D. Starch

**Answers:**
(a) (b)

**Time limit:** 2 minutes.

Do not go onto the next test until you are asked to do so.

M.S.C. Test No. 12: NOVEL TECHNOLOGY

**Instruction:** suggest two improvements for each of the following appliances:

(a) Electric fan
(b) Telephone

**Answers:**
(a) (i) .......................................................
   (ii) .......................................................
(b) (i) .......................................................
   (ii) .......................................................

**Time limit:** 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 13: OUTCOMES

**Instruction:** Note down, in short, the various different consequences of the following:

(a) Substitution of telephone system by TV system.

(b) Complete success in producing synthetic food.

**Answers:**

(a) ............................................................................
............................................................................
............................................................................
............................................................................
............................................................................

(b) ............................................................................
............................................................................
............................................................................
............................................................................
............................................................................

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 14: MATCHED RELATION

Instruction: Choose one of the four pairs of words in each of the problems below with a relation most like that of the underlined pair above them.

Problems:

(a) **Heat – Read**

(1) Cold – Blue
(2) Violet – X. Ray
(3) Cold – White
(4) Orange – Blue

(b) **Diamond – Carbon**

(1) Chalk – Marble
(2) Goblet – Iron
(3) Graphite – lead
(4) Slate – Mute

(c) **ATP – ADP**

(1) DNA – RNA
(2) PbO2 – PbO
(3) Cretine Phosphate – Creatine
(4) TPN – DPN (Tri/ Di Phosphopyridine nucleotide)

Answers: (a) (b) (c)

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 15: VERBAL OPPOSITIONS

Instruction: Write words with opposite relationship to the words given below.

<table>
<thead>
<tr>
<th>Words given:</th>
<th>Answers (opposites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Acceleration</td>
<td>.................................</td>
</tr>
<tr>
<td>(b) Geometric</td>
<td>.................................</td>
</tr>
<tr>
<td>(c) Centrifugal</td>
<td>.................................</td>
</tr>
<tr>
<td>(d) Efflorescence</td>
<td>.................................</td>
</tr>
<tr>
<td>(e) polygenic</td>
<td>.................................</td>
</tr>
<tr>
<td>(f) Ultra</td>
<td>.................................</td>
</tr>
<tr>
<td>(g) Hyper</td>
<td>.................................</td>
</tr>
<tr>
<td>(h) Super</td>
<td>.................................</td>
</tr>
<tr>
<td>(i) Union</td>
<td>.................................</td>
</tr>
<tr>
<td>(j) Photosynthesis</td>
<td>.................................</td>
</tr>
</tbody>
</table>

Time limit: 3 minutes.

After the time limit is over, please close the booklet, examine if the entries on the biodata flap are complete, and hand it over to the examiner.

Be present when the part II of the test is administered later.
MAJUMDAR SCIENTIFIC CREATIVITY TEST

Part II
1982

General Instruction

This is a test for creative thinking in Science. The tests often demand novel and unconventional responses.

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Published by
MANASAYAN
32, NETAJI SUBHASH MARG
NEW DELHI - 110002
M.S.C. Test No. 16: SYMBOL REASONING

Instruction: Each of the rows below – consisting of letters and/or numbers – is arranged in a series. Write the last two of the series, in each:

Example:

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>5</td>
<td>X</td>
<td>10</td>
<td>Y</td>
<td>15</td>
<td>(Z)</td>
<td>(20)</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>9</td>
<td>10</td>
<td>25</td>
<td>36</td>
<td>(49)</td>
<td>(64)</td>
</tr>
</tbody>
</table>

Answers:

Problems:

a) A D G K N Q .....
   .....

b) P S Q T R V .....
   .....

c) B 3 E 6 H 9 .....
   .....

d) 8 10 5 3 6 8 .....
   .....

e) 15 18 22 27 33 40 .....
   .....

Time limit: 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 17: IMPLICATIONS

Instruction: The following symbols stand for some institutes or organizations. Suggest various names.

Example: Answers:

1. Institute of Electronics.
2. Communication Appliances Ltd.
3. Dept. of posts and telegraphs.
4. Electrical Engineers’ Club.

Problems: Answers: (Give as many responses as you can)

(a) (i) (ii) (iii) (iv) (v)

(b) (i) (ii) (iii) (iv) (v)

Time limit: 2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 18: REMOTE ASSOCIATION

Instruction: What will be the different far-reaching consequences of the following:

a) If the velocities of rotation and revolution of the Earth get reduced.

b) If man can travel faster than light.

Answers: (give as many responses as you can):

a) ........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................

b) ........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................

Time limit: 2½ minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 19: SPATIAL ORIENTATION

Instruction: Find which of the five pictures –a, b, c, d, e – can be that of the object in the box at the left, twisted to a changed position, in the problems below:

Problems:

A. Book

B. Apparatus

Answers:

A............. B.............

Time limit: 1 1/2 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 20: CORRELATES

A. WORDS

Instruction: Fill up the blanks to form pairs of analogous words.

Example: Circle–Ellipse; Lens–Prism; Catalyst–Enzyme; Latitude–Longitude.

Problems: Answers:

(a) Laser – ................................................
(b) Isomer – ................................................
(c) DNA – ................................................
(d) Parabola – ............................................
(e) Isotherm – ...........................................

Time limit: 2½ minutes.

Do not go onto the next test until you are asked to do so.

B. NUMBERS

Instruction: Fill up the following blanks with appropriate numbers.


Problems:


b) If: ‘no’ = 45, ‘so’ = 95, ‘to’=? ......


Time limit: 1½ minutes.

Please do not turn over the page until you are asked to do so.
### M.S.C. Test No. 21: COMPREHENSION

**Instruction:** Explain the meaning of the following, in short (a line, or so).

<table>
<thead>
<tr>
<th>(Words)</th>
<th>(Meanings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Laser</td>
<td></td>
</tr>
<tr>
<td>2. DNA</td>
<td></td>
</tr>
<tr>
<td>3. Polymers</td>
<td></td>
</tr>
<tr>
<td>4. Marsupial</td>
<td></td>
</tr>
<tr>
<td>5. Permutation</td>
<td></td>
</tr>
<tr>
<td>6. Helix</td>
<td></td>
</tr>
<tr>
<td>7. Cryogenics</td>
<td></td>
</tr>
<tr>
<td>8. Aromatic</td>
<td></td>
</tr>
<tr>
<td>9. Gaussian</td>
<td></td>
</tr>
<tr>
<td>10. Antipodes</td>
<td></td>
</tr>
</tbody>
</table>

**Time limit:** 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 22: ASSOCIATIONAL FLUENCY

Instruction: Produce various functional synonyms or associational uses of the following words:

<table>
<thead>
<tr>
<th>(Given Words)</th>
<th>functional synonyms:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Plasma</td>
<td></td>
</tr>
<tr>
<td>(b) Frequency</td>
<td></td>
</tr>
<tr>
<td>(c) Cell</td>
<td></td>
</tr>
<tr>
<td>(d) Node</td>
<td></td>
</tr>
<tr>
<td>(e) Substitution</td>
<td></td>
</tr>
<tr>
<td>(f) Mutation</td>
<td></td>
</tr>
<tr>
<td>(g) Parameter</td>
<td></td>
</tr>
<tr>
<td>(h) Harmonic</td>
<td></td>
</tr>
<tr>
<td>(i) Gauss</td>
<td></td>
</tr>
<tr>
<td>(j) Polarity</td>
<td></td>
</tr>
</tbody>
</table>

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
**Appendices**

M.S.C. Test No. 23: **WORD - GROUP NAMING**

**Instruction:** Give a class name to each of the groups of words below:

<table>
<thead>
<tr>
<th>Group of Words</th>
<th>Class – Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a] (i) Light</td>
<td>(ii) Radio - waves</td>
</tr>
<tr>
<td>[b] (i) Mica</td>
<td>(ii) Amber</td>
</tr>
<tr>
<td>[c] (i) Ellipse</td>
<td>(ii) Hyperbola</td>
</tr>
<tr>
<td>[d] (i) Azolitmin</td>
<td>(ii) Phenolphthalein</td>
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<td>[e] (i) Adenine</td>
<td>(ii) Guanine</td>
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M.S.C. Test No. 23: WORD - GROUP NAMING (contd.)

Group of Words: Class – Name:

[f]  (i) Granite .................................................................
    (ii) Diamond .............................................................
    (iii) Marble ............................................................... 
    (iv) Slate ...................................................................

[g]  (i) Kangaroo ............................................................... 
    (ii) Wombat .................................................................
    (iii) Koala - bear ...........................................................
    (iv) Opossum ............................................................... 

[h]  (i) Coniferous ............................................................
    (ii) Deciduous .............................................................
    (iii) Evergreen .............................................................
    (iv) Mangrove ............................................................

[i]  (i) Thiamine ..............................................................
    (ii) Niacin .................................................................
    (iii) Riboflavin ...........................................................
    (iv) Pyridoxine ...........................................................

[j]  (i) Histogram ............................................................
    (ii) Ojive .................................................................
    (iii) Piagram .............................................................
    (iv) Bargraph ...........................................................

Time limit: 3 minutes.
Please do not turn over the page until you are asked to do so.

269
M.S.C. Test No. 24: SYMBOL RELATION

**Instruction:** find out various relationships between symbols from the following given relationships:

(a) **Given:** 
1 eV (electron volt) = \(1.60 \times 10^{-12}\) erg
1 Cal (Calorie) = 4.1840 J.
1 eV = \(1.60 \times 10^{-19}\) J.
Other relations have to be calculated out:

(b) **Given:** 
2X + 5Y = 3m; X + 3Z = Zn; and 3Y + Z = 4P
Other relations have to be calculated out:

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 25:  

**Word grouping**

**Instruction:** Assign the following 16 words to four mutually exclusive classes.

**Given words:** Reciprocal, resonance, elasticity, exhaust, vector, monomial, crystals, abscissa, electrolyte, smoke, polymer, garbage, titration, noise, inertia, sewage.

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**Time limit:** 2 \(1/2\) minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 26: NUMBER ASSOCIATION

Instruction: Solve the following problems by finding out the letter – number association in each.

Problems:

(1) JO = 25, RO = 85, KO =?
(2) CAT = 3120, MAT = 13120, PAT =?
(3) BY = 22, MAY = 1312, WHY =?
(4) COW = 3210, NOW = 14210, HOW =?

Answers: (1) (2) (3) (4)

The space below may used for rough work:

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 27: SIGN CHANGES

A. Instruction: Solve the following equations by changing signs as per rules.

Equations:          Rules:

(1) \((62-48)+16\times 24 = \ldots\ldots\ldots\ldots\) Replace: + with − & 
\div with \times

(2) \((810-790)+(43+27) = \ldots\ldots\ldots\ldots\) Replace: + with − & − with +

Answers: (1) (2)

B. Instruction: Choose changes that make the expressions into equations:

(1) \(3+1=6\times 2\)
(2) \(8+5-1=8\times 6\)

Changes: (a) Instead of + you put −
(b) Instead of + you put \times
(c) Instead of \times you put −
(d) Both (a) and (b)

Answers: (1) (2)

Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 28: DESCRIPTIVE COMPLETION

A. Instruction: Write various completions forming short sentences (in the field indicated in parentheses) in each of the following.

[a] (Physics) The latent heat of........................................................
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[b] (Chemistry) Sulphuric acid is.........................................................
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[c] (Biology) Algae. ...........................................................................
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[d] (Mathematics) The base of...........................................................
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Time limit: 3 minutes.

Please do not turn over the page until you are asked to do so.
M.S.C. Test No. 29: WORD/NUMBER FLUENCY

A. **Instruction**: Give as many responses as possible (an example is provided for each problem, in parentheses)

(a) Produce various scientific or mathematical words ending in ‘...tion’:
(Equation) ...........................................................................................
...............................................................................................
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(b) Produce various scientific or mathematical words beginning with ‘ele’:
(Element) ............................................................................................
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(c) Write multiples of 19 that end in odd digit:
(57) .............................................................................................
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(d) Give various values of mathematical or scientific constants:
\[
\pi = \frac{22}{7}
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**Time limit**: 2 \(\frac{1}{2}\) minutes.

After the time is over, please close the booklet, examine if the entries on the bio-data flap have been made as per instruction, and hand it over to the examiner.

Thank You.
Torrance Test of Creative Thinking (I: Figural)

Activity 1. PICTURE CONSTRUCTION

Below is a piece of colored paper in the form of a curved shape. Think of a picture or an object which you can draw with this piece of paper as a part. On the back of these shapes you will find a thin layer of paper that can be peeled away. Look. Now you can stick your colored shape wherever you want it to make the picture you have in mind. Stick yours on the next page where you want it and press down on it. Then add lines with your pencil or crayon to make your picture.

Try to think of a picture that no one else will think of. Keep adding new ideas to your first idea to make it tell as interesting and as exciting a story as you can.

When you have completed your picture, think up a name or title for it and write it at the bottom of the page in the space provided. Make your title as clever and unusual as possible. Use it to help tell your story.
YOUR TITLE
Activity 2. PICTURE COMPLETION

By adding lines to the incomplete figures on this and the next page, you can sketch some interesting objects or pictures. Again, try to think of some picture or object that no one else will think of. Try to make it tell as complete and as interesting a story as you can by adding to and building up your first idea. Make up an interesting title for each of your drawings and write it at the bottom of each block next to the number of the figure.
Activity 3. CIRCLES

In ten minutes see how many objects or pictures you can make from the circles below and on the next page. The circles should be the main part of whatever you make. With pencil or crayon add lines to the circles to complete your picture. You can place marks inside the circles, outside the circles, or both inside and outside the circles—wherever you want to in order to make your picture. Try to think of things that no one else will think of. Make as many different pictures or objects as you can and put as many ideas as you can in each one. Make them tell as complete and as interesting a story as you can. Add names or titles below the objects.
Torrance Test of Creative Thinking (II: Verbal)

Activities 1-3: ASK-AND-GUESS

The first three activities will be based on the drawing below. These activities will give you a chance to see how good you are at asking questions to find out things that you don't know and in making guesses about possible causes and consequences of happenings. Look at the picture. What is happening? What can you tell for sure? What do you need to know to understand what is happening, what caused it to happen and what will be the result?
Activity 1. ASKING. On this page, write out all of the questions you can think of about the picture on the page opposite this one. Ask all of the questions you would need to ask to know for sure what is happening. Do not ask questions which can be answered just by looking at the drawing. You can continue to look back at the drawing as much as you want to.

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Activity 2. GUESSING CAUSES: In the spaces below, list as many possible causes as you can of the action shown in the picture on page 2. You may use things that might have happened just before the things that are happening in the picture, or something that happened a long time ago that made these things happen. Make as many guesses as you can. Don't be afraid to guess.

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Activity 3. GUESSING CONSEQUENCES: In the spaces below, list as many possibilities as you can of what might happen as a result of what is taking place in the picture on page 2. You may use things that might happen right afterwards or things that might happen as a result long afterwards in the future. Make as many guesses as you can. Don't be afraid to guess.

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Activity 4: PRODUCT IMPROVEMENT

In the middle of this page is a sketch of a stuffed Joy monkey of the kind you can buy in most dime stores for about one to two dollars. It is about six inches tall and weighs about six ounces. In the spaces on this page and the next one, list the cleverest, most interesting and unusual ways you can think of for changing this toy monkey so that children will have more fun playing with it. Do not worry about how much the change costs. Think only about what would make it more fun to play with as a toy.

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Appendices

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Activity 5: UNUSUAL USES (Tin Cans)

Most people throw their tin cans away, but they have thousands of interesting and unusual uses. In the spaces below and on the next page, list as many of these interesting and unusual uses as you can think of. Do not limit yourself to any one size of can. You may use as many cans as you like. Do not limit yourself to the uses you have seen or heard about; think about as many possible new uses as you can.

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Activity 6: UNUSUAL QUESTIONS

In this activity, you are to think of as many questions as you can about tin cans. These questions should lead to a variety of different answers and might arouse interest and curiosity in others concerning tin cans. Try to think of questions about aspects of tin cans which people do not usually think about.

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Activity 7: JUST SUPPOSE

You will now be given an improbable situation—one that will probably never happen. You will have to just suppose that it has happened. This will give you a chance to use your imagination to think out all of the other exciting things that would happen if this improbable situation were to come true.

In your imagination, just suppose that the situation described were to happen. THEN think of all of the other things that would happen because of it. In other words, what would be the consequences? Make as many guesses as you can.

The improbable situation—JUST SUPPOSE a great fog were to fall over the earth and all we could see of people would be their feet. What would happen? How would this change life on the earth? List your ideas and guesses on the next page.