PHYSICS – Paper 2020 (Solved)

SECTION I (40 Marks)

*Attempt **all** questions from this section.*

Question 1

(a) (i) Define moment of force. **[2]**

(ii) Write the relationship between the S.I. and C.G.S. unit of moment of force.

Ans. (i) The moment of force is equal to the product of the magnitude of the force and the perpendicular distance of the line of action of the force from the axis of rotation.

(ii) S.I. unit, 1 N m = 10^5 dyne × 10^2 cm = 10^7 dyne cm

(b) Define a kilowatt hour. How is it related to joule ? **[2]**

Ans. One kilowatt hour is the electrical energy consumed by an electrical appliance of power 1 kilowatt when it is used for 1 hour.

1 kilowatt hour = 1 kilowatt × 1 hour

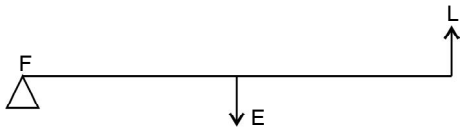
= 1000 J s^{-1} × 3600 s = 3·6 × 10^6 J

(c) A satellite revolves around a planet in a circular orbit. What is the work done by the satellite **at any instant** ? Give a reason. **[2]**

Ans. The work done is zero because the centripetal force on the body at any instant is directed towards the centre of the circular path and the displacement at that instant is along the tangent to the circular path, *i.e.* normal to the direction of force on the body. Since θ = 90°, cos 90° = 0. Therefore, work done is zero.

(d) (i) Identify the class of the lever shown in the diagram alongside :

(ii) How is it possible to increase the M.A. of the above lever without increasing its length ? **[2]**



Ans. (i) It is a class III lever.

(ii) By applying effort at a larger distance from the fulcrum *i.e.* shifting effort E towards load L, thereby increasing the length of efform arm.

(e) Give one example of each when : **[2]**

(i) Chemical energy changes into electrical energy. (ii) Electrical energy changes into sound energy.

Ans. (i) In a battery when current is drawn from it in the external circuit.

(ii) In a loud speaker, electrical signals vibrate the diaphragm of loud speaker to produce sound.

Question 2

(a) A crane **'A'** lifts a heavy load in 5 seconds, whereas another crane **'B'** does the same work in 2 seconds. Compare the power of crane **'A'** to that of crane **'B'**. **[2]**

Ans. Let the work done by both cranes be **'W'**.

Given : Time taken by crane A to do work W, t_1 = 5 s

Time taken by crane B to do work W, t_2 = 2 s

$\therefore$ Power of crane A, $P_A = \frac{W}{t_1}$

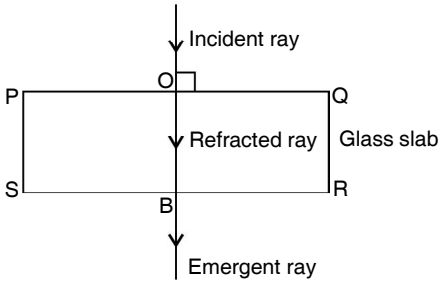
Power of crane B, $P_B = \frac{W}{t_2}$

$\therefore$ $\frac{P_A}{P_B} = \frac{Wt_2}{Wt_1} = \frac{2}{5}$

$P_A : P_B = 2 : 5$

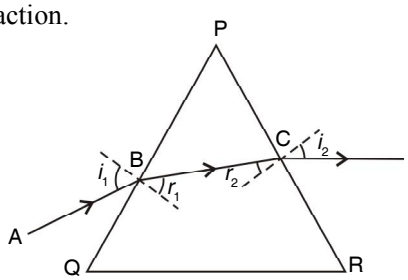
(b) A ray of light falls normally on a rectangular glass slab. Draw a ray diagram showing the path of the ray till it emerges out of the slab. **[2]**

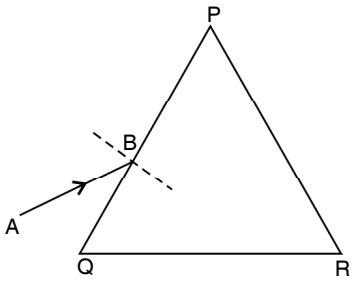
Ans.



(c) Complete the path of the monochromatic light ray AB incident on the surface PQ of the equilateral glass prism PQR till it emerges out of the prism due to refraction. **[2]**

Ans.





(d) Where should an object be placed in front of a convex lens in order to get : **[2]**

(i) an enlarged real image. (ii) enlarged virtual image ?

Ans. (i) Object should be placed between F_1 (or f) and $2F_1$ (or $2f$) distance *i.e.* $2F_1 > u > F_1$.

(ii) Object should be placed between F_1 and optical centre *i.e.* $u < F_1$.

(e) A pond appears to be 2·7 m deep. If the refractive index of water is $\frac{4}{3}$, find the actual depth of the pond. **[2]**

Ans. Refractive index of the liquid $= \dfrac{\text{Actual depth}}{\text{Apparent depth}}$

$$\frac{4}{3} = \frac{\text{Actual depth}}{2{\cdot}7}$$

$$\text{Actual depth} = \frac{4}{3} \times 2{\cdot}7 = \mathbf{3{\cdot}6\ m}$$

Question 3

(a) The wave lengths for the light of red and blue colours are nearly $7{\cdot}8 \times 10^{-7}$ m and $4{\cdot}8 \times 10^{-7}$ m respectively. **[2]**

(i) Which colour has the greater speed in a vacuum ?

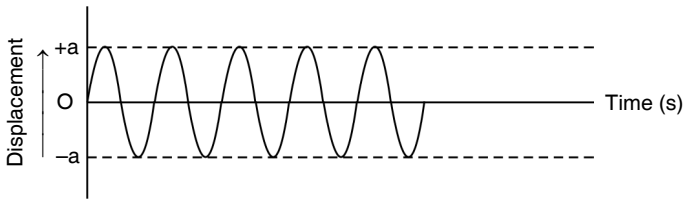
(ii) Which colour has a greater speed in glass ?

Ans. (i) The speed is same for light of both colours in vacuum.

(ii) Light of red colour has greater speed in glass.

(b) Draw a graph between displacement from mean position and time for a body executing free vibration in a vacuum. **[2]**

Ans.



(c) A sound wave travelling in water has wavelength 0·4 m. Is this wave audible in air ? (The speed of sound in water = 1400 ms^{-1}). **[2]**

Ans. The frequency of wave $= \dfrac{\text{Speed}}{\text{Wavelength}} = \dfrac{1400}{0{\cdot}4} = 3500$ Hz or 3·5 kHz

This lies in the audible range of frequency (*i.e.* 20 Hz to 20,000 Hz), hence it is audible.

(d) Why does stone lying in the sun get heated up much more than water lying for the same duration of time ? **[2]**

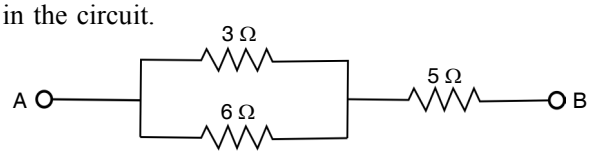
Ans. It is because the specific heat capacity of water is more than that of stone. With the same exposure to sun, stone acquires higher temperature due to its low specific heat capacity.

(e) Why is it not advisable to use a piece of copper wire as fuse wire in an electric circuit ? **[2]**

Ans. Copper, due to its high conductivity, low specific resistance and high melting point, does not melt when heated up and thus does not break the flow of current in the circuit.

Question 4

(a) Calculate the total resistance across AB : **[2]**



Ans. Since resistances 3 Ω and 6 Ω are in parallel, their equivalent resistance R_p is given by

$$\frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} \quad \therefore \; R_p = 2\ \Omega$$

$\therefore$ Total resistance across AB is 2 + 5 = **7 Ω**

(b) Two metallic blocks P and Q having masses in ratio 2 : 1 are supplied with the same amount of heat. If their temperatures rise by same degree, compare their specific heat capacities. **[2]**

Ans. Let mass of block P = m_P and mass of block Q = m_Q.

Given : $\dfrac{m_P}{m_Q} = \dfrac{2}{1}$

$Q = ms\,\Delta t$

Since heat supplied (ΔQ) and rise in temperature (Δt) is same for both block P and Q,

$\therefore \quad m_P\, s_P\, \Delta t = m_Q\, s_Q\, \Delta t$

or $\dfrac{s_P}{s_Q} = \dfrac{m_Q}{m_P} = \dfrac{1}{2}$

$\therefore \quad s_P : s_Q = \mathbf{1 : 2}$

(c) When a current carrying conductor is placed in a magnetic field, it experiences a mechanical force. What should be the angle between the magnetic field and the length of the conductor so that the force experienced is : **[2]**

(i) Zero (ii) Maximum ?

Ans. (i) Force experienced is zero when conductor is parallel to the magnetic field so the angle between them is **zero**.

(ii) Force experienced is maximum when conductor is perpendicular to the magnetic field *i.e.* when the angle between conductor and field is equal to **90°**.

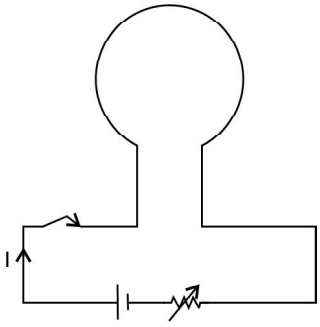
(d) A nucleus ${}_{84}X^{202}$ of an element emits an alpha particle followed by a beta particle. The final nucleus is ${}_{a}Y^{b}$. Find a and b. **[2]**

Ans. ${}^{202}_{84}X \longrightarrow {}^{198}_{82}Z + {}^{4}_{2}He$ (α particle emission)

${}^{198}_{82}Z \longrightarrow {}^{198}_{83}Y + {}^{0}_{-1}e$ (β particle emission)

$\therefore \; a = \mathbf{83}, \; b = \mathbf{198}$

(e) The diagram alongside shows a loop of wire carrying current I : **[2]**



(i) What is the magnetic polarity of the loop that faces us ?

(ii) With respect to the diagram how can we increase the strength of the magnetic field produced by this loop?

Ans. (i) **South pole** as current is clockwise at this face.

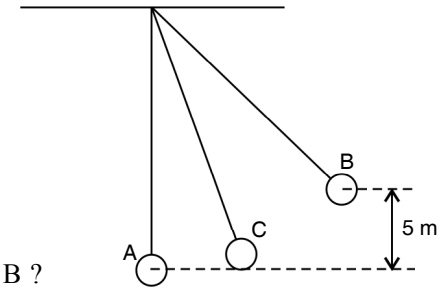
(ii) By decreasing the value of variable resistance, so as to increase the current I in the circuit.

SECTION II (40 Marks)

*Attempt any **four** questions from this section.*

Question 5

(a) The figure alongside shows a simple pendulum of mass 200 g. It is displaced from the mean position A to the extreme position B. The potential energy at the position A is zero. At the position B the pendulum bob is raised by 5 m. **[3]**



(i) What is the potential energy of the pendulum at the position B ?

(ii) What is the total mechanical energy at point C ?

(iii) What is the speed of the bob at the position A when released from B ?
(Take g = 10 ms^{-2} and there is no loss of energy).

Ans. Given : h = 5 m, m = 200 g = 0·2 kg, g = 10 ms^{-2}

(i) Potential energy U_B at B is given by

U_B = m.g.h. = 0·2 × 10 × 5 = **10 J**

(ii) Total mechanical energy at C is same as at all points of the path (conservation of mechanical energy)

= **10 J**

(iii) At A, bob has only kinetic energy which is equal to potential energy at B,

$$\therefore \quad \frac{1}{2}\, mv_A^2 = U_B$$

$$0{\cdot}5 \times 0{\cdot}2 \times v_A^2 = 10 \quad \therefore v_A = \sqrt{100} = \mathbf{10\ ms^{-1}}$$

(b) (i) With reference to the direction of action, how does a centripetal force differ from a centrifugal force during uniform circular motion ? **[3]**

(ii) Is centrifugal force the force of reaction of centripetal force?

(iii) Compare the magnitudes of centripetal and centrifugal force.

Ans. (i) Centripetal force always acts towards the centre of circle along its radius. It is this force which compels the body to move along the circular path. A centrifugal force appears to act away (outward) from the centre of circular path. Thus, the two forces act in opposite directions.

(ii) No.

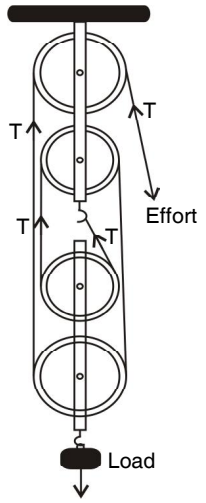
(iii) The two forces have equal magnitude.

(c) A block and tackle system of pulleys has velocity ratio 4. **[4]**

(i) Draw a neat labelled diagram of the system indicating clearly the points of application and direction of load and effort.

(ii) What will be its V.R. if the weight of the movable block is doubled ?

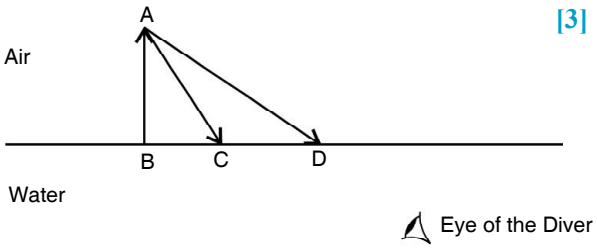
Ans. (i)



(ii) Increase in weight of movable block does not affect velocity ratio. Therefore, V.R. = 4.

Question 6

(a) A diver in water looks obliquely at an object AB in air. **[3]**

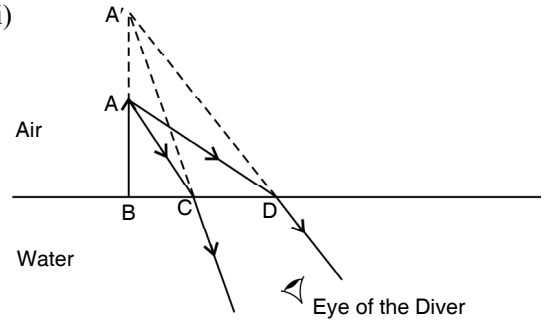


(i) Does the object appear taller, shorter or of the same size to the diver ?

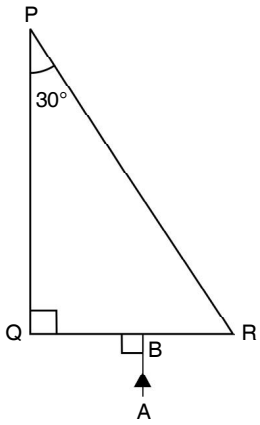
(ii) Show the path of two rays AC and AD starting from the tip of the object as it travels towards the diver in water and hence obtain the image of the object.

Ans. (i) The object appears taller to the diver.

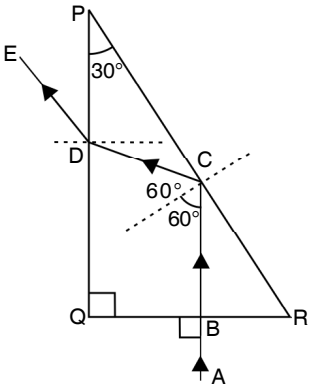
(ii)



(b) Complete the path of the ray AB through the glass prism in PQR till it emerges out of the prism. Given the critical angle of the glass as 42°. **[3]**



Ans.



Note that total internal reflection takes place at C.

(c) A lens of focal length 20 cm forms an inverted image at a distance 60 cm from the lens. **[4]**

(i) Identify the lens.

(ii) How far is the lens present in front of the object ?

(iii) Calculate the magnification of the image.

Ans. (i) Convex lens.

(ii) Given $f = +20$ cm, $v = +60$ cm, $u = ?$

From lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\frac{1}{20} = \frac{1}{60} - \frac{1}{u} \quad \therefore \; u = -30$ cm

The lens is at a distance of **30 cm** from the object.

(iii) Magnification, $m = \frac{v}{u} = \frac{60}{-30} = -2$ *i.e.* 2 times.

Question 7

(a) Give reasons for the following : **[3]**

During the day : (i) Clouds appear white. (ii) Sky appears blue

Ans. (i) Clouds are dust particles and water molecules suspended in the atmosphere near the earth of size bigger than the wavelength of visible light. Thus, they scatter all colours of incident white light from the sun to the same extent and hence when scattered light reaches our eyes, the clouds appear white.

(ii) The air molecules in the atmosphere scatter the blue end of spectrum having shorter wavelengths much more than colours on the red end. In the absence of direct light from sun, the light reaching our eyes is the scattered light which is rich in blue colour. Hence light from all directions of sky being rich in blue colour makes the sky appear blue.

(b) (i) Name the system which enables us to locate underwater objects by transmitting ultrasonic waves and detecting the reflecting impulse. **[3]**

(ii) What are acoustically measurable quantities related to pitch and loudness ?

Ans. (i) It is called sound navigation and ranging or SONAR. Here ultrasonic waves from a ship are transmitted in all directions. The reflected waves received in the receiver gives the distance and position of the object (e.g. submarine, etc.) in water.

(ii) The measurable quantity related to pitch is **frequency** and to loudness is **intensity** of sound.

(c) (i) When a tuning fork [vibrating] is held close to ear, one hears a faint hum. The same [vibrating tuning fork] is held such that its stem is in contact with the table surface, then one hears a loud sound. Explain. **[3]**

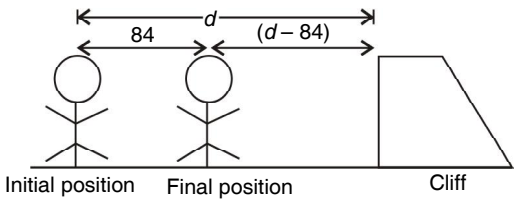
(ii) A man standing in front of a vertical cliff fires a gun. He hears the echo after 3·5 seconds. On moving closer to the cliff by 84 m, he hears the echo after 3 seconds. Calculate the distance of the cliff from the initial position of the man.

Ans. (i) When the stem of the tuning fork is placed in contact with a table top, it sets the table surface in small vibrations but the large number of air molecules in contact with the table surface also start vibrating, thereby producing a loud sound.

(ii) Let the man be standing at distance d from the cliff and v be the speed of sound in air.

For first echo, $t_1 = \dfrac{2d}{v} = 3{\cdot}5$ s ....(i)

and for second echo, $t_2 = \dfrac{2(d-84)}{v} = 3$ s ....(ii)

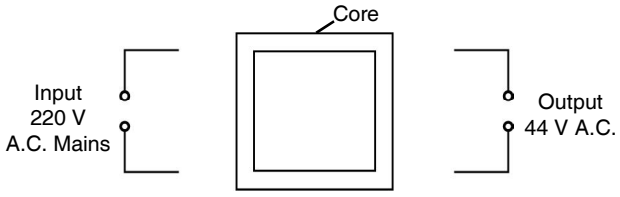


Dividing eqn. (ii) by eqn. (i)

$\dfrac{d-84}{d} = \dfrac{3}{3{\cdot}5}$ or d = **588 m**

Question 8

(a) The diagram alongside shows the core of a transformer and its input and output connections. **[3]**

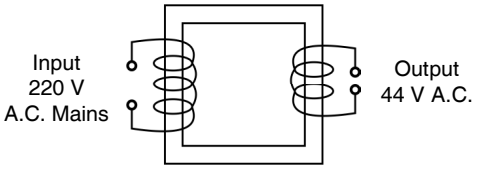


(i) State the material used for the core.

(ii) Copy and complete the diagram of the transformer by drawing input and output coils.

Ans. (i) The core is made of soft iron.

(ii)



(b) (i) What are superconductors ? **[3]**

(ii) Calculate the current drawn by an appliance rated 110 W, 220 V when connected across 220 V supply.

(iii) Name a substance whose resistance decreases with the increase in temperature.

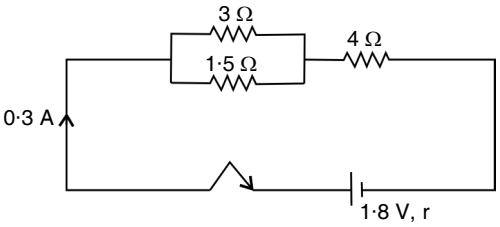
Ans. (i) Alloys of certain materials have almost zero resistance near the absolute zero temperature. These are called superconductors.

(ii) For the given appliance, W = 110 W, V = 220 V

$$\therefore \text{Current I} = \frac{W}{V} = \frac{110}{220} = \mathbf{0{\cdot}5\ A}$$

(iii) The resistance of semiconductors such as carbon, silicon, etc. decreases with increase in temperature.

(c) The diagram alongside shows three resistors connected across a cell of e.m.f. 1·8 V and internal resistance *r*. Calculate : **[3]**



(i) Current through 3 Ω resistor.

(ii) The internal resistance *r*.

Ans. (i) The equivalent resistance R_p of resistances 3 Ω and 1·5 Ω joined in parallel is given by

$$\frac{1}{R_p} = \frac{1}{3} + \frac{2}{3} = 1 \quad \therefore R_p = 1\ \Omega$$

So the potential drop across this combination is = 0·3 × 1 = 0·3 V

$$\therefore \text{Current through 3 Ω resistance} = \frac{\text{Voltage}}{\text{Resistance}} = \frac{0{\cdot}3}{3} = \mathbf{0{\cdot}1\ A}$$

(ii) Total resistance of the circuit = $R_p + 4 + r = (5 + r)\ \Omega$

(iii) Current in the circuit, $0{\cdot}3 = \frac{1{\cdot}8}{5+r}$

On solving, internal resistance of cell r = **1 Ω**

Question 9

(a) (i) Define heat capacity of a substance. **[3]**

(ii) Write the S.I. unit of heat capacity.

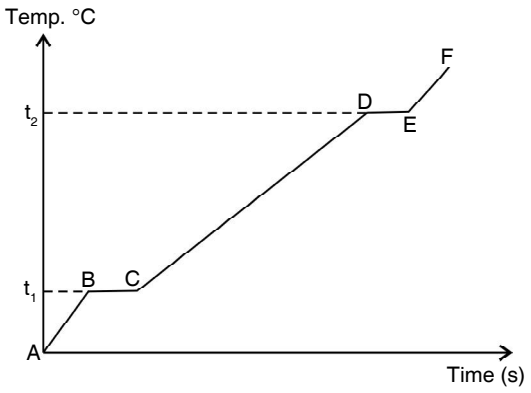
(iii) What is the relationship between heat capacity and specific heat capacity of a substance ?

Ans. (i) The heat required to raise the temperature of a substance or body through 1°C (or 1 K) is called its heat capacity.

(ii) S.I. unit is J $°C^{-1}$ or J K^{-1}.

(iii) Specific heat capacity = $\frac{\text{Heat capacity}}{\text{Mass of body or substance}}$

(b) The diagram alongside shows the change of phases of a substance on a temperature vs time graph on heating the substance at a constant rate. **[3]**



(i) Why is the slope of CD less than slope of AB ?

(ii) What is the boiling and melting point of the substance ?

Ans. (i) In part CD, the rate of rise in temperature is slow as the substance in this phase has high specific heat capacity while temperature rises rapidly in part AB (so higher slope) as the substance has lower specific heat capacity in this phase. The different specific heat capacities are attributed to different phases of state (*i.e.* solid and liquid phase).

(ii) Boiling point of substance is t_2, and melting point of substance is t_1.

(c) A piece of ice of mass 60 g is dropped into 140 g of water at 50°C. **[4]**

Calculate the final temperature of water when all the ice has melted. (Assume no heat is lost to the surrounding)

Specific heat capacity of water (c) = 4·2 J/g°C

Specific latent heat of fusion of ice (L) = 336 Jg^{-1}

Ans. Let final temperature of water be T°C.

Heat energy taken by the ice to melt at 0°C

Q_1 = mass of ice × specific latent heat of fusion of ice

= 60 g × 336 J g^{-1} = 20,160 J

Heat energy taken by the melted ice to raise its temperature from 0°C to T°C

Q_2 = mass of ice × specific heat capacity of water × rise in temperature

= 60 g × 4·2 J/g°C × (T – 0)°C = 252 T J

Total heat energy taken by ice = $Q_1 + Q_2$

= (20,160 + 252 T) J ....(i)

Heat energy given by water in fall of its temperature from 50 °C to T°C

= mass of water × specific heat capacity of water × fall in temperature

= 140 g × 4·2 J/g°C × (50 – T)°C

= 588 (50 – T) J ....(ii)

If there is no heat loss, heat energy given by water

= total heat energy taken by ice

588 (50 – T) = 20,160 + 252 T

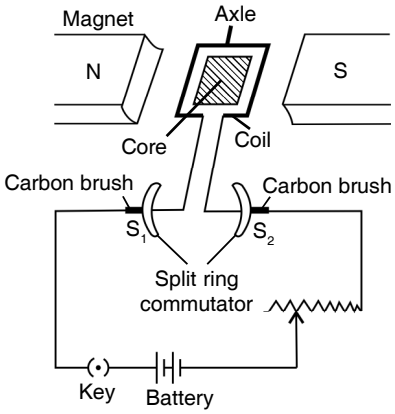
T = **11°C**

Question 10

(a) (i) Draw a neat labeled diagram of a d.c. motor. **[3]**

(ii) Write any one use of a d.c. motor.

Ans. (i) The completed neat labeled diagram of a d.c. motor is shown alongside.



(ii) It is used to produce rotational motion in appliances like fan, mixer, grinder, washing machine, etc.

(b) (i) Differentiate between nuclear fusion and nuclear fission. **[3]**

(ii) State one safety precaution in the disposal of nuclear waste.

Ans. (i) Nuclear fusion is the process of combining light nuclei to form a larger nuclei at very high temperature and pressure with the release of energy, while nuclear fission is the process of breaking of a heavy nucleus in two nearly equal fragments with the release of energy.

(ii) The nuclear waste should be enclosed in thick casks and buried in deep underground places far from populated areas.

(c) An atomic nucleus **A** is composed of 84 protons and 128 neutrons. The nucleus **A** emits an alpha particle and is transformed into a nucleus **B**. **[4]**

(i) What is the composition of B ?

(ii) The nucleus B emits a beta particle and is transformed into a nucleus C. What is the composition of C ?

(iii) What is mass number of the nucleus A ?

(iv) Does the composition of C change if it emits gamma radiations ?

Ans. (i) Nucleus B has 82 protons and 126 neutrons.

(ii) Nucleus C has 83 protons and 125 neutrons.

(iii) Mass number of nucleus A is 212.

(iv) No, the energy level of nucleus C is lower now.