

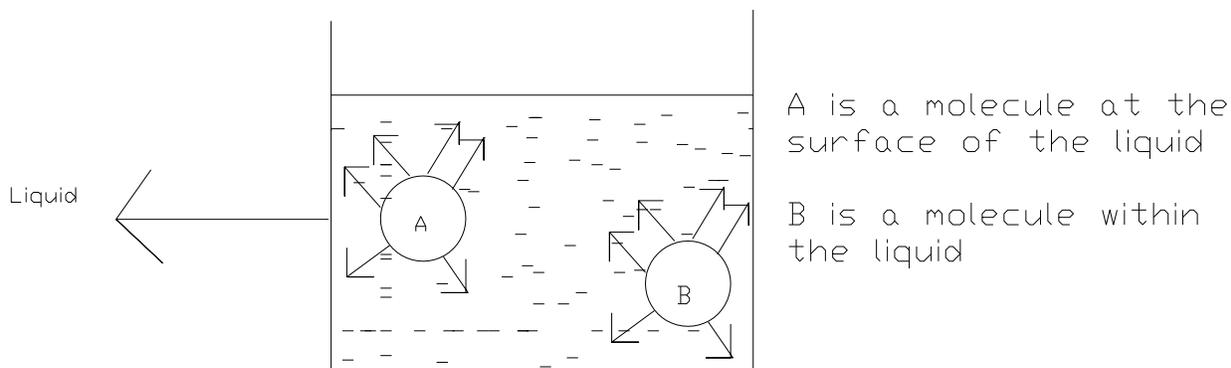
**2005 MAY/JUNE NBC/NTC EXAMINATIONS**

**MODERN QUESTIONS AND ANSWER – PHYSICS**

Question 1

- a. Explain the sources of surface tension in a liquid
- b. Why would a ship made of steel float in water, whereas steel sinks in water?
- c. How would you determine the volume of an irregular – shaped object?
- d. An amount of mercury of relative density 13.6 is put in a U-tube. Kerosene of relative density 0.8 is poured into one arm of the U-tube to reduce the height of mercury in that arm by 1.5 cm. Determine the height of the kerosene column

Answer 1a. Surface tension is due to the forces of attraction between the molecules of the liquid



There is a force of attraction between molecules in a liquid. In the diagram above, molecule B will feel equal attraction from other molecules in all directions around it, hence the net force acting on it will be zero, while molecule A experiences no attraction from above but more attraction inside the liquid tending to pull it down. All molecules on the surface thus

feel this net attractive force into the bulk of the liquid. In this way a tensional force exist on the surface between adjacent molecules tending to cause the liquid surface to shrink. The force between like molecules of the liquid is called cohesive force. The surface tension force act as if there is an elastic film stretched across the surface of the liquid.

Answer 1b. A ship made of steel floats on water because the overall density of the structure, that is the mass divided by the volume is less than that of water, whereas the density of steel (elemental iron mixed with carbon) is much greater than that of water. It will sink into the water.

Answer 1c. To determine the volume of an irregularly shaped object, I will employ Archimedes principle

A measuring cylinder is filled with water to a known level  $V_1$ , which is noted. The irregularly shaped object is completely immersed in the water. The water level in the cylinder will go up. This new level is recorded  $V_2$ .

From Archimedes principle, the body will displace its own volume of the liquid in which it is immersed.

therefore  $V_2 - V_1 = \text{Volume of the object immersed}$

Answer 1d

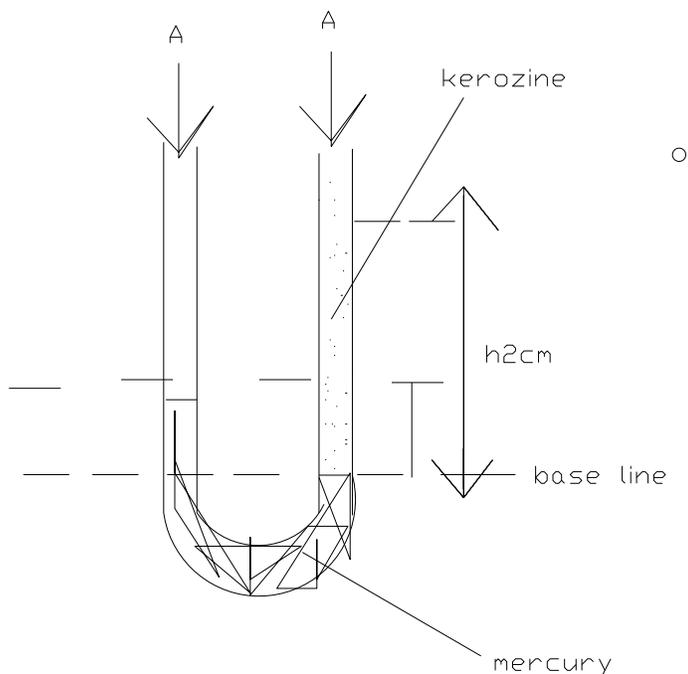
From  $h_1 e_1 = h_2 e_2$ . The pressure on either side of the baseline is the same.

$$h_1 = 1.5, e_1 = 13.6 \text{ gm/cc}$$

$$h_2 = x, e_2 = 0.8 \text{ gm/cc}$$

$$1.5 \times 13.6 = h_2 \times 0.8$$

$$h_2 = \frac{1.5 \times 13.6}{0.8} = 25.5 \text{ cm}$$



The height of the kerosene column = 25.5cm

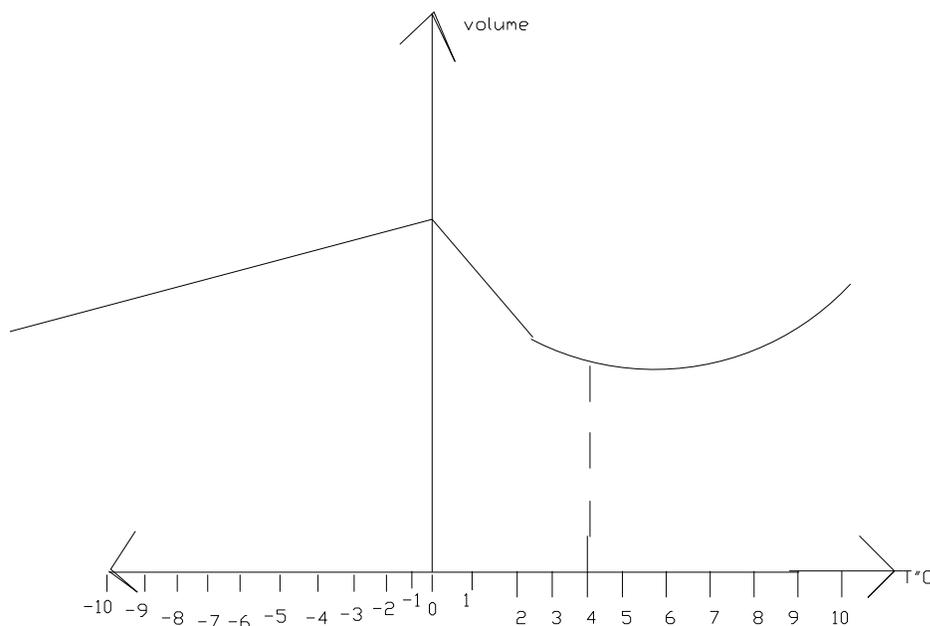
Question 2:

- a. State the meaning of the terms
  - i. Mechanical energy
  - ii. joule
- b. How do you explain the rise in temperature of a bicycle pump during the action of pumping up the tyre?
- c. Sketch a graph (not to scale), of volume temperature for the range between  $+10^{\circ}\text{C}$  and  $-10^{\circ}\text{C}$  of water
- d.
  - i. Describe how you would check the accuracy of the fixed points of a mercury thermometer
  - ii.
    - a. A compound strip of brass and iron is straight at room temperature. Give a labeled diagram to show its appearance when it is cooled.
    - b. Describe one use of such a strip

Answer 2a.

- i. Mechanical Energy is the capacity for doing work either by virtue of a body's position in space (or elastic state) or by virtue of its motion. Mechanical energy comprises of Potential Energy + Kinetic energy.
- ii. Joules: This is a unit of energy. 1 Joule is the work done when 1 Newton of forces acts on a body to move it through a distance of 1 metre in the direction the force is acting. It is a scalar quantity.

Answer 2b The rise in temperature of a bicycle pump during the action of pumping up the tyre can be explained thus. Work done against friction in the barrel is translated into heat which cause the temperature of the pump to rise.



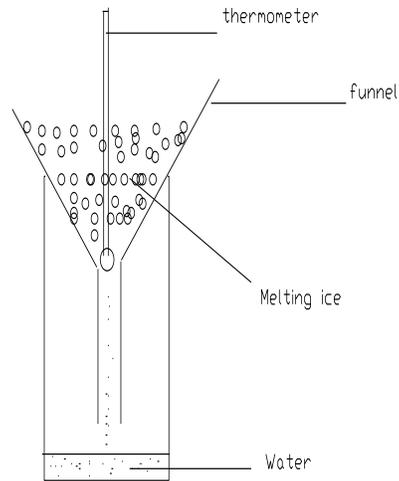
Volume – Temperature graph of water between  $-10^{\circ}\text{C}$  to  $+10^{\circ}\text{C}$ . water has maximum density at about  $4^{\circ}\text{C}$ .

Answer 2d(i) To check the accuracy of the fixed points of a mercury Thermometer.

There are two fixed points of a thermometer, the lower and upper fixed points

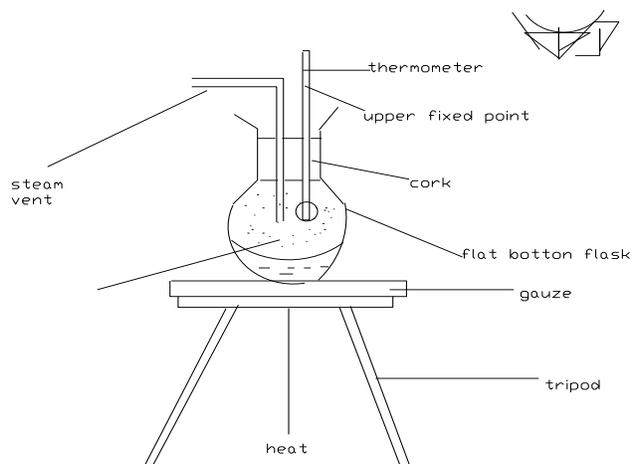
To check the lower fixed point

Check the barometer reading to be at 760 mm Hg.



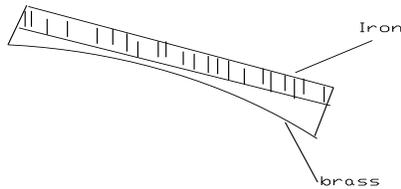
Insert the thermometer inside a mixture of ice and water (melting ice) as shown above. After the mercury level in the capillary (stem) has remain steady for some time. Note whether this corresponds to the  $0^{\circ}\text{C}$  mark on the thermometer. If not then, the lower fixed point is not accurate.

To check the upper fixed point:



The arrangement shown in diagram above is used. The thermometer is suspended above the water in the flask, but not touching it. Heat is applied to the water in the flask. When it has been boiling for sometime, with the steam playing on most part of the stem, the mercury thread will be seen to settle at a point and the point is noted. If the Barometric pressure in the laboratory is 760 mm Hg then the position of the mercury thread of the thermometer should correspond to that of the upper fixed point. If not, there is an error in locating the upper fixed point.

Answer 2d, (ii) (a)

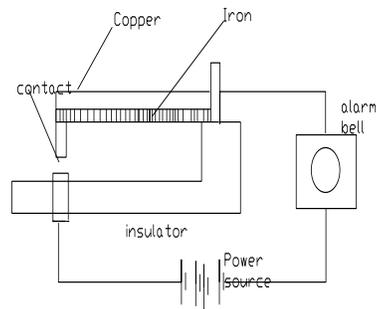


When cooled the brass will contract more than the iron. The strip will bend as shown with the brass inside the curve.

Answer 2d(ii)b Use of Bimetallic Strip (Any of these)

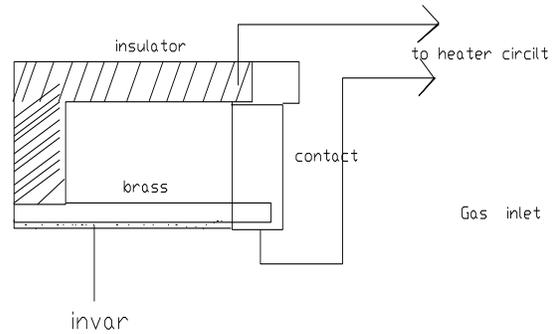
- i. Electric fire alarm
- ii. Gas oven thermostat
- iii. Electric iron thermostat
- iv. Balance wheel of a clock
- v. Thermometer

Description of Electric fire Alarm



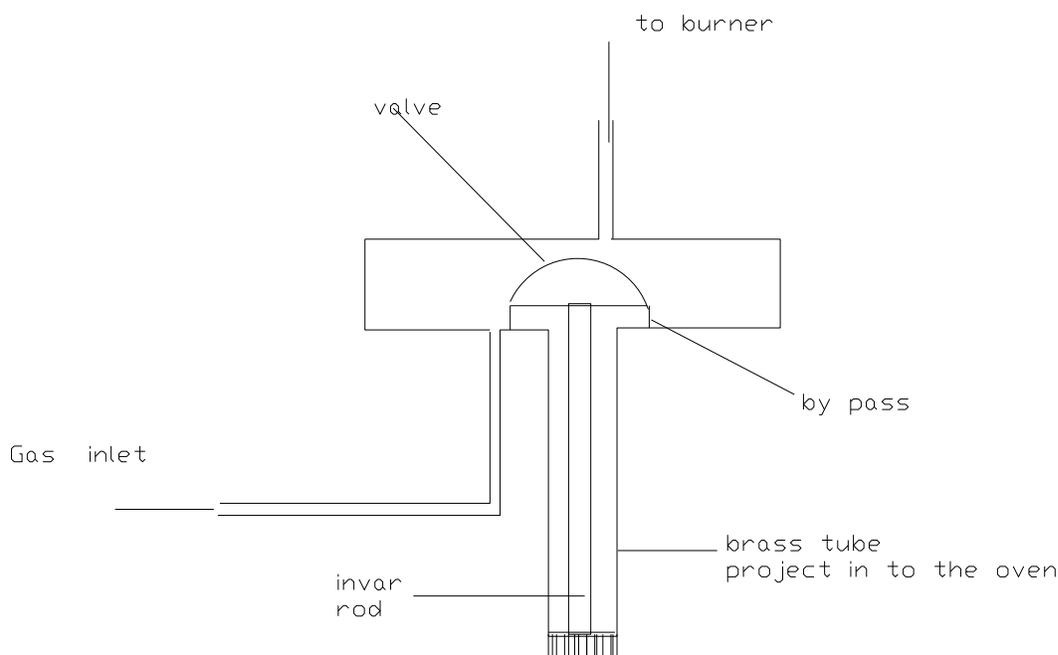
The diagram shows an automatic fire alarm. When there is fire the heat cause the copper to expand more than the iron over the same temperature rise. When the temperature of the place where it is fixed reach a certain predetermined value the bimetallic strip curve inward and the contact point closes. This set the current flowing and causes the alarm bell to ring.

ELECTRIC THERMOSTAT



The diagram above is used to control the temperature of an electric heating device. Electric current can flow as long as the contact remains touching. When the temperature around the bimetal strip made of invar and brass reach a predetermined value, it bends away from the contact as brass expands more than invar (which have very low thermal coefficient of expansion). The contacts are broken and current ceases. On cooling, the contact is again remade and the heater is switched on.

Gas thermostat:



The diagram above shows the Gas thermostat. The brass tube projects into the oven. As the oven temperature rises, the brass tube expands causing the invar rod, which hardly expands to move downwards. The invar in turn moves the valve down reducing the gap between the By-Pass and it, thus reducing the gas flow. At a predetermined temperature the valve will completely be pulled down tightly on the by-pass thus shutting of the gas supply completely

When the oven cools the brass tube contracts, thus moving the invar up thus in turn opens the valve and the gas flow is allowed again.

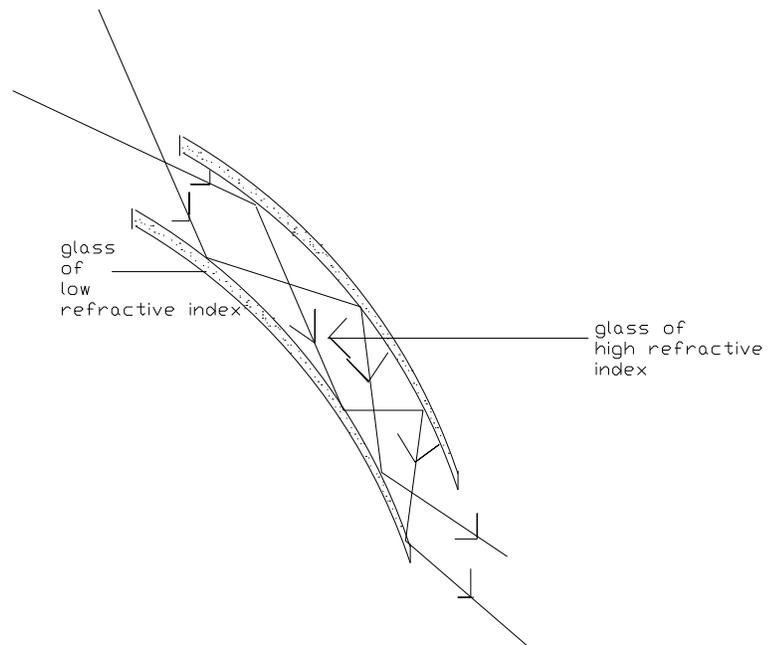
Question 3:

- a. Explain TWO applications of total internal reflection
- b. Describe and explain the action of a rear reflector on a bicycle.
- c. Give the relationship between the angle of rotation of a mirror and the angle of deflection of a reflected ray, when the direction of the incident ray is constant.
- d. You are supplied with converging lenses, focal length 50cm, 5cm and 0.5cm. which would you use as:
  - i. The objective lens of a compound microscope?
  - ii. The eyepiece of a compound microscope?
  - iii. A magnifying glass? (Give reasons).

Answer 3 (a) Application of total internal reflection (Any two)

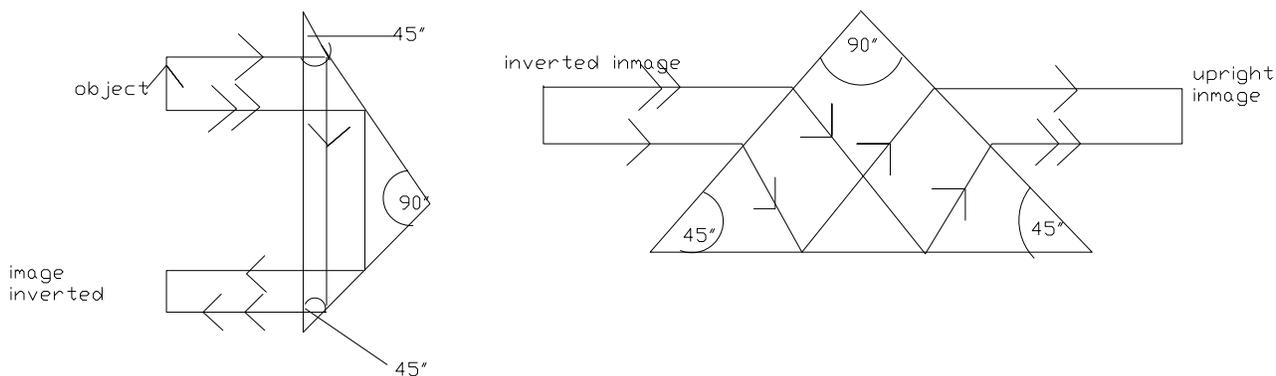
- i. Fibre optics
- ii. Totally reflecting Prisms
- iii. Prism image inverter or used in projection lantern
- iv. Prism Binoculars
- v. Prism periscope,
- vi. Camera view finder

Fiber optics: This is application of total internal reflection.



When light passes from a more dense medium to a less dense one striking the interface (boundary) at an angle greater than the critical angle it will suffer total internal reflection. A ray of light enters the glass of high refractive index. As a result of successive reflection at the boundary it travels down the length of the glass tube/fibre. The fibre is usually about  $2\mu\text{m}$  in diameter and it is flexible. The fibres are tightly packed in bundles; they can be bent into different shapes. They are used to light up inaccessible places and to transmit pictures/information from one place to another.

Totally Reflecting Prisms:



This prism is a right angled isosceles triangular prism. They are used in Periscope, prismatic binoculars, cameras and projection lanterns. The critical angle for glass is about  $41^{\circ}48'$ . when light enters the prisms as shown it strikes the hypotenuse face at an angle greater than the critical angle and therefore suffer total internal reflection inside the prism following the path shown to get out of the prism.

Answer 3b. Action of the Rear reflector on a Bicycle. The rear reflector of a bicycle is made up of red coloured glass or plastic. The surface is rough so that when light is shone on it, the beam is scattered in all directions (diffuse reflection). Since the colour is red, the red portion of the light spectrum is scattered more.

Answer 3c. The relationship between the angle of rotation of a mirror and the angle of deflection of a reflected ray when the incident ray remain stationary is:

If mirror is turned through an angle  $\theta$ ; the reflected ray will turn through  $2\theta$

But the angle between the incident ray and the new reflected ray is  $2(i+\theta)$

Hence the angle of deflection of the incident ray from its original path =  $180 - 2(i+\theta)$

- Answer 3d.
- (i) the 0.5cm focal length lens – to give a small aperture
  - (ii) The 5.0cm focal length lens – to give a wide aperture
  - (iii) The 50cm focal length lens – so that object will always be inside the focal length.

Question 4 (a) Explain magnetic induction and state how you would test for the exact polarity.

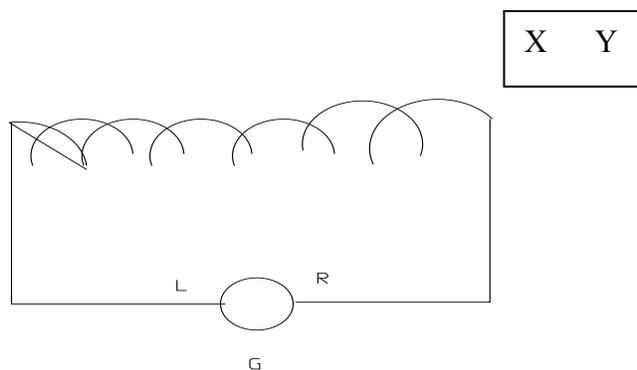
Answer: 4(a) 1. Magnetic induction is the strength of magnetic field in a space or region, it is a vector quantity, it is denoted by a letter B; it is also called magnetic flux density, its unit is Weber per metre<sup>2</sup> (w/m<sup>2</sup>) or tesla (T).

OR

2. Induced magnetism – when a piece of iron rod is placed in the direction of the earth’s magnetic field (or a known magnetic field) the magnetic field temporarily magnetizes the rod. The phenomenon is called magnetic induction.

Answer 4a. to test for the exact polarity of a magnet:-

OPTION 1



Galvanometer

Lenz's law of Electromagnetic induction states that the induced current is in such a direction as to oppose the change producing it by its magnetic action. If the pole of magnet marked X is north-pole, then when it is moved towards the coil the galvanometer should deflect to the right hand side and if this pole is South Pole then it will move to the left when the magnet is moved towards it. In this way the pole of the magnet can be determined exactly.

OPTION 2



Through the use of magnet of known polarity

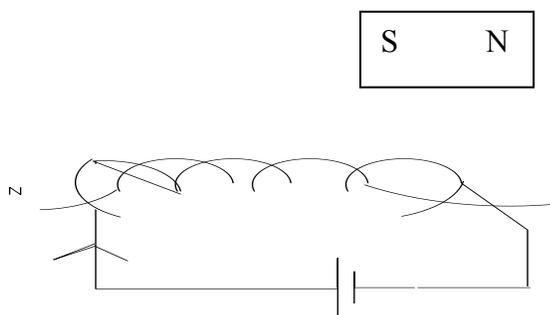
Bring a magnet clearly marked N and S to one end of unknown magnet. The end which is repelled by the N – pole of the known magnet is the N – pole while its other end is the S – pole.

OPTION 3

Have a coil with a current passing through it in an anticlockwise manner from left to right

Then the L.H.S. of the coil is the N – pole while the R.H.S. of the coil is the S – pole.

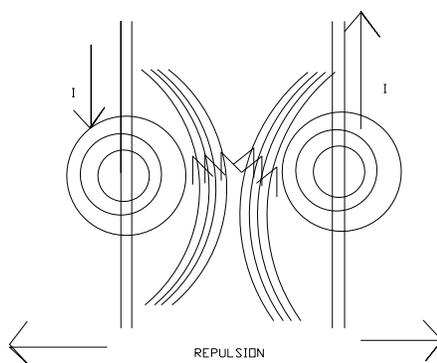
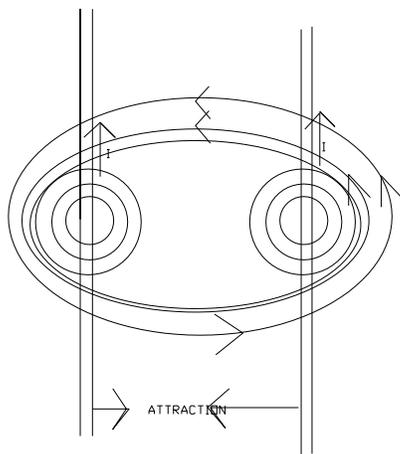
If a magnet is brought close to it from the R.H.S.  
If it repels, then that is the S – pole of the magnet.



But if it attracts, that is the N – pole of the magnet.

Question 4b. Two vertical wires are suspended side by side without making contact. Electric current flows through the wires in the same direction and then in opposite direction. Draw the lines of force surrounding the wires in each case, neglect the earth's magnetic field.

Answer 4b.



When the current are in the same direction there is attraction between them, the magnetic lines are not very close in between them compared to outside them. but when the current flows in opposite direction there is repulsion between them.

Question 4(c) Give two applications of electromagnets.

Answer 4(c) Applications of electromagnets (Any two)

1. To produce an intense magnetic field in generators and electric motors
2. Used for lifting and transporting heavy iron bearing objects.
3. Can be used to spate ferrous metals from non-ferrous metals.
4. They are used in electric bells and telephone earpiece

Question 4(d) An electric of charge  $1.6 \times 10^{-19} \text{C}$  moves horizontally through a vertical magnetic field of  $0.01 \text{ Wb/m}^2$  with a speed of  $1.5 \times 10^8 \text{ ms}^{-1}$ . calculate:

- i. the force acting on the electrons
- ii. The acceleration of the electron

Answer 4d (i) Charge  $q = -1.6 \times 10^{-19} \text{C}$ , Electron Mass =  $9.1 \times 10^{-31} \text{kg}$

Magnetic flux density =  $0.01 \text{ wb/m}^2$

Velocity of charge  $V = 1.5 \times 10^8 \text{ m/s}$

Force =  $qVB = qvB \sin\theta$ ;  $\theta = 90^\circ$

Force =  $qVB$

$$= 1.6 \times 10^{-19} \times 1.5 \times 10^8 \times 0.01 \text{ N}$$

$$F = \underline{1.6 \times 1.5 \times 10^{-13} \text{N}}$$

$$F = \underline{2.4 \times 10^{-13} \text{N}}$$

$$\text{ii. Acceleration, } a = \frac{F}{m} = \frac{2.4 \times 10^{-13} \text{N}}{9.1 \times 10^{-31} \text{Kg}}$$

$$a = \frac{24}{9.1} \times 10^{18} \text{ m/s}^2$$

$$= 0.2637 \times 10^{18} \text{ m/s}^2$$

$$\underline{\underline{a = 2.637 \times 10^{17} \text{ m/s}^2}}$$

Question 5(a)(i) State TWO phenomena that can only be satisfactorily explained by the assumption that matter behaves like:

1. Waves
2. Particles

Answer 5(a)(i) Wave nature (a) Electron diffraction/light diffraction

(b) Light refraction or reflection

Particle nature (a) Photo electric effect

(b) Compton Scattering of X-ray

(c) Emission and absorption of light

(d) Thermonic emission

Question 5a(ii) A bullet of mass 0.02kg is fired with a velocity of  $10^3$  m/s. calculate the rest of the energy of the bullet

Answer 5a (ii)

Mass of bullet	=	0.02kg	Vel. of light	=	$3.0 \times 10^8$ m/s
Velocity of bullet	=	$10^3$ m/s			
Rest Energy	=	$m_0 C^2$			
	=	$0.02 \times (3.0 \times 10^8)^2$ j			
	=	$2 \times 10^{-2} \times 9.0 \times 10^{16}$ j			
	=	$18.0 \times 10^{14}$ joules			

Question 5b(i) Explain binding energy of a nucleus

Answer 5b(a) The Nucleus of an atom is made up of protons and neutrons. Each has a mass. When the total masses of all the protons and neutrons are added, it is found to be more than the mass of the actual nucleus they compose. This deficit in mass is responsible for the energy holding the nucleus together. This Nuclear binding energy is given by Einstein relation.

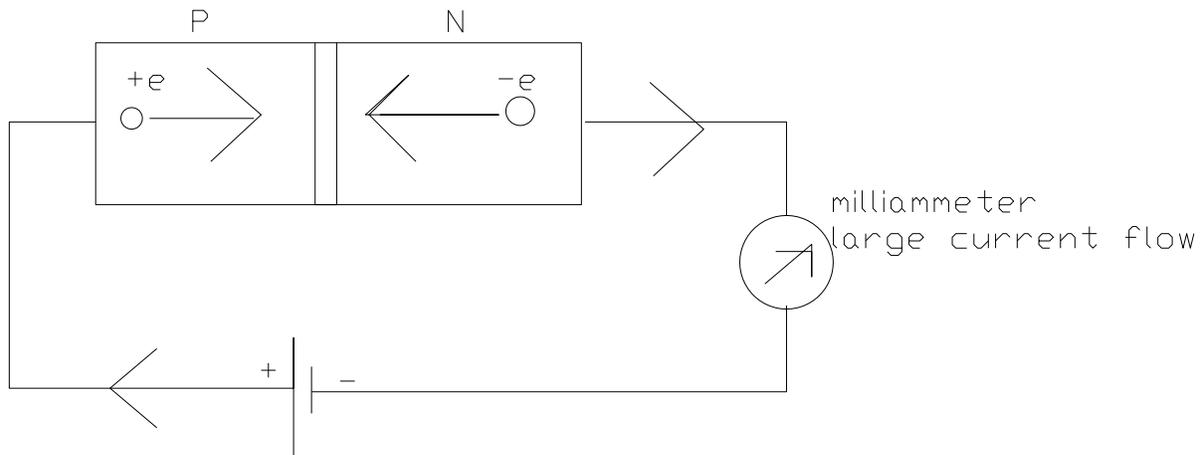
$$\left\{ \begin{array}{l} \Delta E = \Delta M C^2 \\ \text{Where } \Delta M = \text{The Mass deficit} \\ C = \text{Velocity of light} = 3.0 \times 10^8 \text{ m/s} \end{array} \right\}$$

This energy will have to be supplied in order to separate the nucleus of the atom against the forces holding them together. This energy is about  $10^6$  times greater than what is required to remove an electron from the atom. This energy can be released through the process of Fission and Fusion.

Question 5b(ii) Describe what happens when a P – n junction diode is:

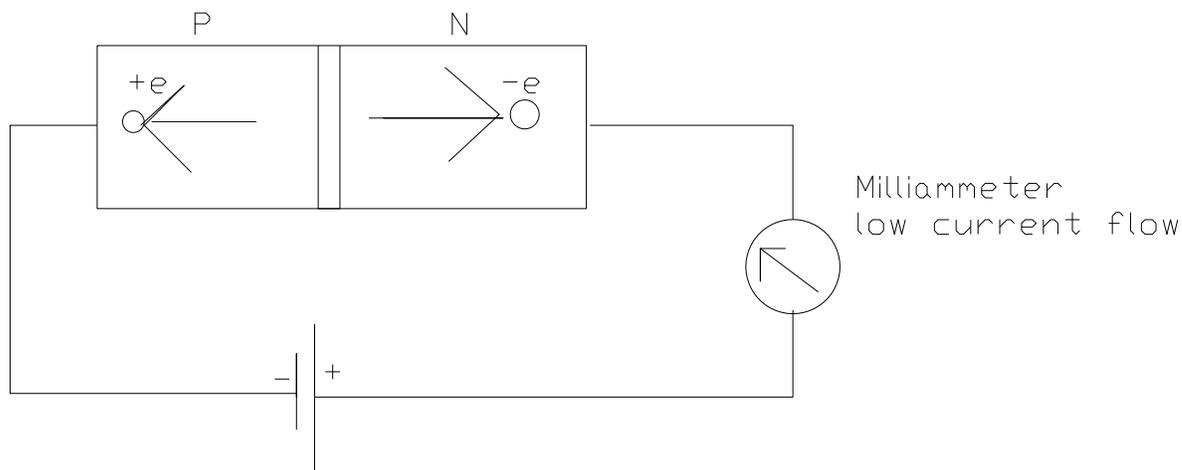
1. Forward biased
2. Reverse biased

Answer 5b(ii) P – N junction Forward biased:



When forward biased large current can flow, the positive hole and the negative electrons are being forced together across the junction and since unlike charges have attraction for each other, the resistance to current flow is low in this case. The current voltage characteristics is shown in figure

2. P – N Junction reverse biased



In the reverse biased condition electrons and holes are being forced apart. This requires more energy and current does not flow easily. In this case the junction exhibits high resistance.

Question 5 (c) State three advantages and one disadvantage of a junction diode over a thermionic valve

Answer 5(c) Advantages of a P-N junction over thermionic valve (Any three)

- i. It is smaller in size
- ii. It does not require a heater to operate to produce electrons
- iii. It requires very low voltages to operate; therefore it can be operated with dry cell batteries of few volts.
- iv. It requires no warm up time to produce electron, these are already inherently available.
- v. Less likely to break

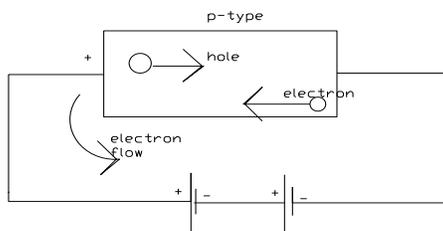
Disadvantages (Any one)

- (i) They conduct slightly in the reverse biased condition
- (ii) They are temperature dependent.

Question 5d. Explain in terms of electrons and holes, how current is conducted in a:

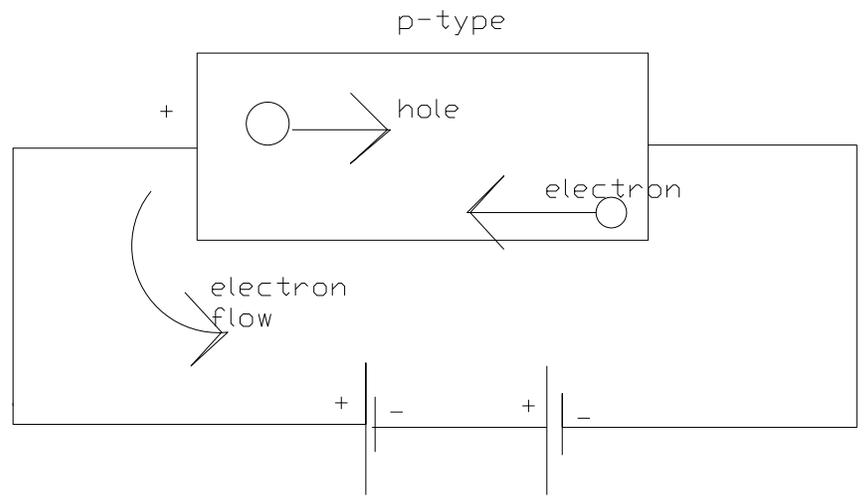
- i. P – type semi-conductor
- ii. N-type semi-conductor

Answer 5d.(i) P-type semi-conductor



In the P-type semiconductor holes are majority carrier. When P.D. is applied as shown above, the holes are urged towards the negative terminal while the electrons are urged towards the positive terminal of the battery

- iii. N-type semiconductor



The extra electrons are free to conduct electricity. In this case, electrons are majority carrier. When a P-D is applied, the electrons are urged towards the positive terminals thus causing current to flow in the external circuit.