P510/2
PHYSICS
Paper 2
Nov./Dec. 2012
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer **five** *questions, taking at least* **one** *from each of the sections A, B C and D, but* **not** *more than* **one** *question should be chosen from either section* **A** *or* **B**.
Any additional questions answered will **not** *be marked.*
Mathematical tables and squared paper will be provided.
Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}\ m$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6}\ \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$

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SECTION A

1. (a) (i) State the **laws of refraction of light.** *(02 marks)*

(ii) State the conditions for total internal reflection to occur. *(02 marks)*

(b) (i) Describe an experiment to determine refractive index of a liquid using an air cell. *(06 marks)*

(ii) Explain the difficulty encountered in the experiment described in (b) (i) if white light is used. *(02 marks)*

(c) A cube of glass of sides 3cm and refractive index 1.5 is placed on a thin film of liquid as shown in figure **1**.

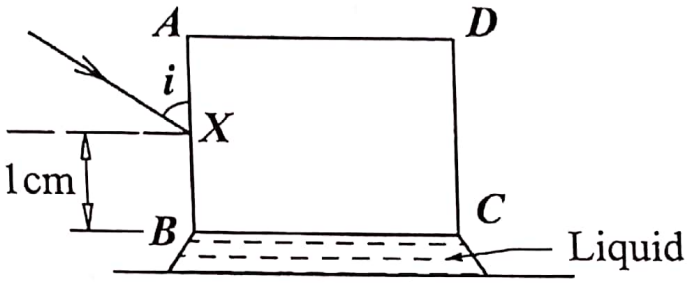

Fig. 1

A ray of light in a vertical plane strikes side *AB* of the glass cube at an angle $i = 41°$. After refraction at *X*, the ray is reflected at the critical angle for the glass – liquid interface.

(i) Calculate the critical angle for the glass – liquid interface. *(03 marks)*

(ii) Find the position from *B* where the ray strikes the glass – liquid interface. *(02 marks)*

(d) Explain why the rays from the sun can still be seen shortly after sunset. *(03 marks)*

2. (a) With the aid of ray diagrams, explain the following as applied to lenses.

(i) Conjugate points. *(02 marks)*

(ii) Spherical aberration. *(02 marks)*

(b) An object, *O*, placed in-front of a converging lens forms a real image, *I* on the screen. The distance between the object and its real image is, *d*, while that of the image from the lens is *x*.

Derive the expression for the least possible distance between the object and its real image. *(05 marks)*

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(c) Give the properties of the lenses in an achromatic combination. *(03 marks)*

(d) A compound microscope consists of two converging lenses of focal lengths 1.0cm and 5.0cm respectively. An object is placed 1.1cm from the objective and the microscope is adjusted so that the final image is formed 30cm from the eye- piece. Calculate;

(i) the separation of the lenses. *(03 marks)*

(ii) the magnifying power of the lenses. *(03 marks)*

(e) State **two** differences between a compound microscope and an astronomical telescope. *(02 marks)*

SECTION B

3. (a) What is meant by the following terms as applied to sound?

(i) Resonance. *(01 mark)*

(ii) Fundamental frequency. *(01 mark)*

(b) Describe an experiment to determine the end – correction of a resonance – tube. *(05 marks)*

(c) A wire of length 50 cm, density 8.0 gcm^{-3} is stretched between two points. If the wire is set to vibrate at a fundamental frequency of 15 Hz, calculate

(i) the velocity of the wave along the wire. *(03 marks)*
(ii) the tension per unit area of cross-section of the wire. *(03 marks)*

(d) Explain using the principle of superposition of waves the formation of

(i) beats. *(04 marks)*
(ii) stationary waves *(03 marks)*

4. (a) (i) What is **plane polarized light**? *(01 mark)*
(ii) Why is it not possible to polarize sound waves? *(01 mark)*

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(b) (i) Unpolarised light is incident on a sheet of polaroid, A, as shown in figure 2.

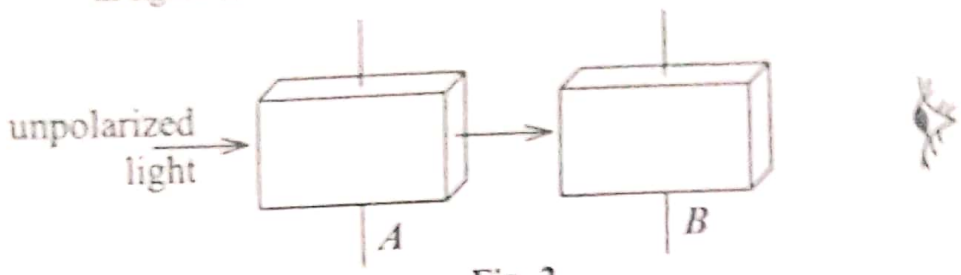

Fig. 2

Explain what would be observed if a second polaroid sheet B is rotated about an axis perpendicular to the direction of incidence. *(03 marks)*

(ii) Sunlight is reflected off a glass window of refractive index 1.55. What should the elevation of the sun be if the reflected light is to be completely polarized? *(03 marks)*

(c) Given the diffraction grating and a spectrometer, describe how you would use them to measure the wavelength of light from a given source. *(07 marks)*

(d) A parallel beam of monochromatic light of wavelength 650 nm is directed normally to a diffraction grating which has 600 lines per mm. Determine

(i) the number of diffraction images. *(03 marks)*

(ii) the angle of diffraction of the highest order diffraction image. *(02 marks)*

SECTION C

5. (a) Define the following:

(i) Weber. *(01 mark)*

(ii) Ampere. *(01 mark)*

(b) A circular coil of N turns, each of radius R carries a current I.

(i) Write an expression for the magnetic flux density at the centre of the coil. *(01 mark)*

(ii) Sketch the magnetic fields pattern associated with the coil. *(02 marks)*

(c) Describe how a deflection magnetometer can be used to investigate the variation of magnetic flux density at the centre of a circular coil with the current flowing through the coil. *(06 marks)*

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(d) Two parallel wires P and Q, each of length 0.2 m carry currents of 10 A and 1 A respectively in opposite directions as shown in figure 3.

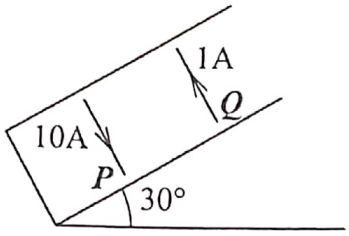

Fig. 3

The distance between the wires is 0.04 m. If both wires remain stationary and the angle of the plane with the horizontal is 30°, calculate the weight of Q. *(05 marks)*

(e) (i) State why the damping in the ballistic galvanometer should be as small as possible. *(01 mark)*

(ii) Describe how the damping can be reduced in practice. *(03 marks)*

6. (a) (i) Define the terms self-induction and mutual induction. *(02 marks)*

(ii) State Faraday's law of electromagnetic induction. *(01 mark)*

(b) (i) Describe the structure and action of an a.c transformer. *(06 marks)*

(ii) Explain why the voltage at a generating power station must be stepped up to a very high value for long distance transmission. *(03 marks)*

(c) In figure 4, a conducting rod PQ of length 20 mm rests on a smooth conducting frame to form a complete circuit of resistance 4.0 Ω. When a force, F, is applied, the rod moves at a constant velocity of 6.0 ms^{-1} perpendicular to a uniform magnetic field of flux density 1.5T.

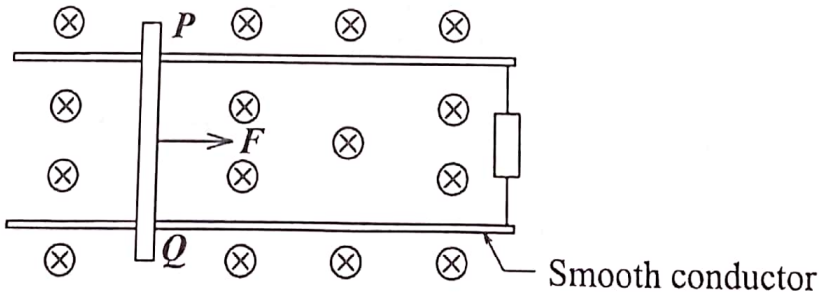

Fig. 4

(i) Explain why the rod PQ moves with constant velocity. *(03 marks)*

(ii) Calculate the magnitude of the induced e.m.f. *(02 marks)*

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(iii) Calculate the magnitude of the force, F. *(03 marks)*

7. (a) Define the term peak value and root mean square value of an alternating current. *(02 marks)*

(b) A coil of many turns of wire is connected in parallel with an electric bulb to a d.c. supply as shown in figure 5.

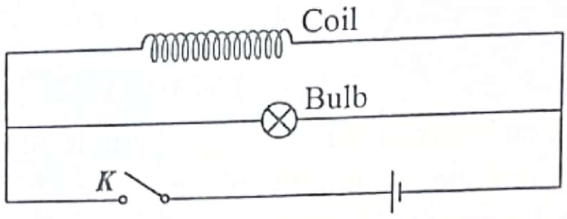

Fig. 5

At the instant switch K is closed, the bulb flashes briefly for a short time and then goes off. Explain the observation. *(04 marks)*

(c) A sinusoidal alternating voltage of 20 V (rms) and frequency 60 Hz is applied across a coil of wire of inductance 0.2 H and negligible resistance.

(i) Find the reactance of the coil at this frequency. *(03 marks)*

(ii) Calculate the rms value of the current which passes through the coil. *(02 marks)*

(iii) Explain why on average the power delivered to the inductor in one cycle is zero. *(03 marks)*

(d) Describe with the aid of a labelled diagram the structure and action of a hot wire ammeter. *(06 marks)*

SECTION D

8. (a) What is meant by **electromotive force of a cell**? *(01 mark)*

(b) Describe an experiment to determine e.m.f and internal resistance of a cell using an ammeter, a resistance box and a voltmeter. *(05 marks)*

(c) (i) Define **temperature coefficient of resistance**. *(01 mark)*

(ii) Explain why the resistance of a thermistor reduces when current is passed through it. *(02 marks)*

(d) (i) Derive the balance conditions for a wheatstone bridge. *(04 marks)*

(ii) Explain **one** reason other than faulty apparatus and poor electrical contact, why it may not be possible to obtain balance in a wheatstone bridge in an experiment to compare two resistances. *(02 marks)*

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(e) In an experiment to investigate the variation of resistance with temperature, a nickel wire and a 10 Ω standard resistor were connected in the left-hand gap and right-hand gap respectively of a metre bridge. When the nickel wire is at $0^{\circ}C$, a balance point is 40 cm from the end of the bridge adjacent to the nickel wire. When the nickel wire is at $100^{\circ}C$, the balance point is 50 cm from the same end of the bridge.
Calculate the temperature of the nickel wire if the balance length is 42 cm. *(05 marks)*

9. (a) (i) What is meant by electric field intensity at a point? *(01 mark)*

(ii) Describe how distribution of charge on a charged conductor of the shape shown in figure 6 can be investigated. *(04 marks)*

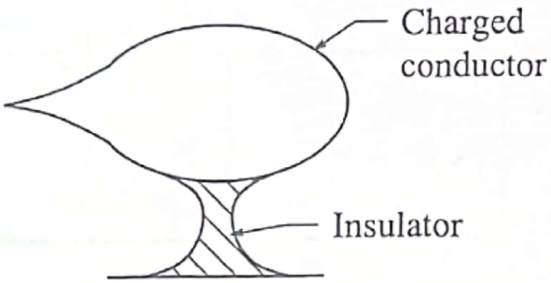

Fig. 6

(iii) Explain how a lighting conductor protects a house from lightening. *(04 marks)*

(b) (i) What is an **electric field line**? *(01 mark)*

(ii) Derive the expression for the electric potential at a point a distance, a, from an isolated charge of magnitude Q in air. *(04 marks)*

(c) Figure 7 shows charges q_1, q_2 and q_3 of +46.3μC, - 34.7μC and +23.4μC respectively, placed in a straight line in air.

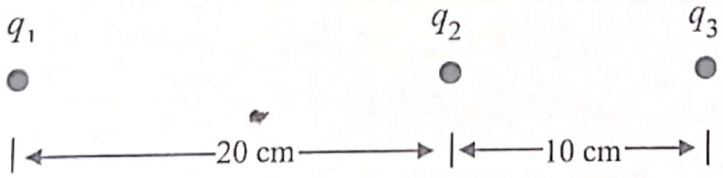

Figure 7

Find the force on q_3. *(06 marks)*

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10. (a) Define the following terms:

(i) the farad. *(01 mark)*

(ii) relative permittivity. *(01 mark)*

(b) You are provided with the following apparatus, a battery, two switches, a capacitor of known capacitance, a ballistic galvanometer and connecting wires.

Describe an experiment that can be carried out using the above apparatus to determine the unknown capacitance of a capacitor. *(05 marks)*

(c) The diagram in Figure **8** shows an arrangement of three capacitors C_1, C_2 and C_3 of capacitance 8 μF, 2 μF and 6 μF respectively.

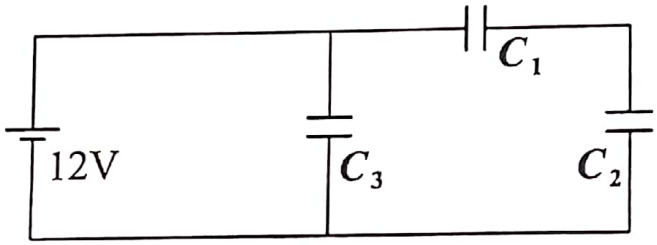

Fig. 8

Calculate the total energy stored:

(i) in all the capacitors when fully charged. *(04 marks)*

(ii) when the space between the plates of C_2 is filled with a dielectric of constant 1.25. *(04 marks)*

(d) A capacitor of capacitance C is charged by a battery and then later isolated. When the plates of the capacitor are taken apart, deduce what happens to the potential difference between the plates. *(03 marks)*

(e) Explain what happens if a conductor instead of a dielectric is placed between the plates of a charged capacitor. *(02 marks)*

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margm

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margm (1)

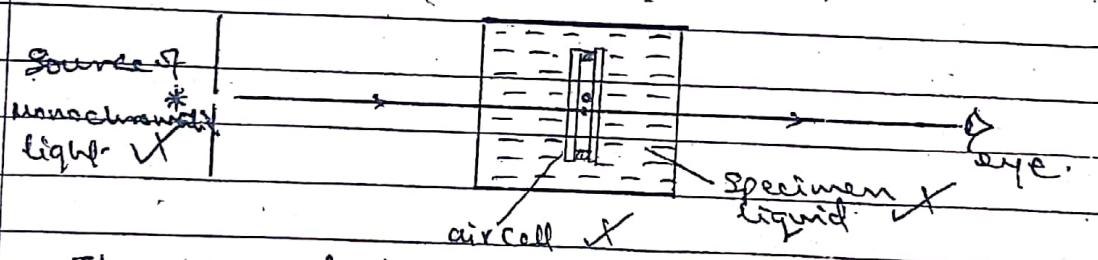
1(a)(i) - The incident ray, the refracted ray, and the normal at the point of incidence, all lie in the same plane.

- The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for a given pair of media (2)

(ii) - Light must be travelling from an optically denser medium to a less dense medium.

- The angle of incidence in the optically denser medium must be greater than the critical angle for the pair of media. (2)

b)



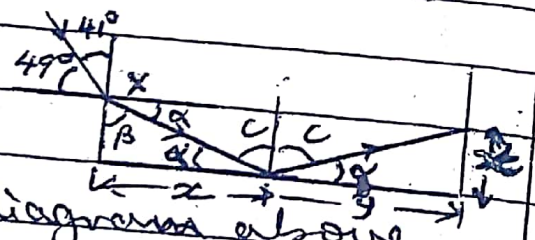
The liquid is poured into a parallel sided transparent vessel. Light from monochromatic source is made incident normally on the vessel, and viewed from opposite side. The air cell is placed in the vessel so that it is illuminated normally on one side. The position of the air cell T_1 is noted. The air cell is now rotated in one direction, keeping the light in view, until light is suddenly cut off from the observer. The angle θ_1,

through which the air cell was rotated is noted. The air cell is restored to position T_1, it is again rotated in opposite direction until light is suddenly cut off. The angle θ_2, of rotation is noted. The average angle of turn θ, is calculated from $\theta = \frac{\theta_1 + \theta_2}{2}$. (2)

Refractive index n_l of the liquid is calculated from $n_l = \frac{1}{\sin\theta}$. (6)

(ii) – If white light is used, the extinction of light is gradual and ill defined. This is because the refractive index of the liquid for the different colours are different, making the angles of refraction different, hence the different colours are cut-off at different points. (2)

c) (i)



From diagram above,

At X, $n_a \sin 49° = n_g \sin\alpha$

$\Rightarrow \sin\alpha = \frac{\sin 49°}{1.50}$

$\Rightarrow \alpha = 30.2°$

But $\alpha + c = 90°$. (3)

$\Rightarrow c = 90 - 30.2$

$= 59.8°$

(ii)

From the diagram

$\beta = 90 - \alpha$

$= 90 - 30.2$

$= 59.8°$

Now $z = 1 \tan\beta$

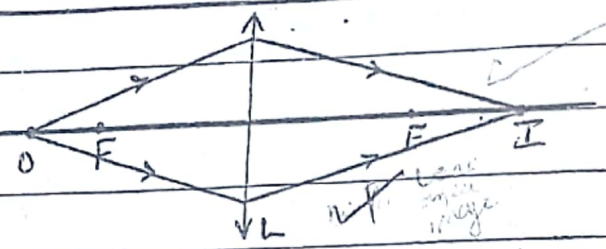
$= \tan 59.8°$

$= 1.72\,cm$ (2)

(d) As the sun sets, layers of air near the earth get cooler, and therefore more dense than layers of air higher up. Light from the sun is therefore continually refracted towards the normal. Rays of light which would propagate ~~above bend~~ away from the earth are therefore refracted on to the earth. When received by an observer on earth, they give an impression of presence of the sun above the horizon. (3)

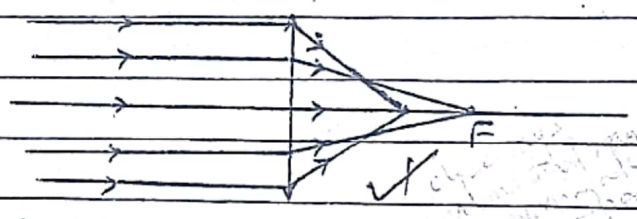
(3)

2(a) (i)



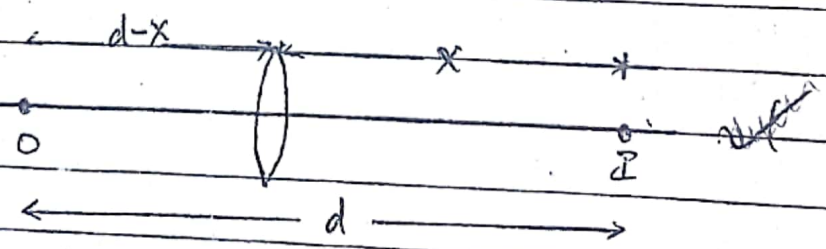
Consider an object placed at point O in front of the lens L, it forms an image at I. From the principle of reversibility of light, when the object is placed at I, the image will be formed at O. The points O and I are therefore interchangeable for object and image, and are called conjugate points.

(ii)



When a wide beam of monochromatic light is incident on a converging lens of wide aperture, marginal rays are brought to focus nearer the lens than the central rays. The image viewed is blurred. This is called spherical aberration.

(b)



Suppose an object placed at O forms image at I as above, then

$u = d - x$ and $v = x$

using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.

(5)

$$\frac{1}{f} = \frac{1}{d-x} + \frac{1}{x}$$

$$\frac{1}{f} = \frac{d}{x(d-x)} \quad \therefore x^2 - dx + df = 0.$$

for real values of x, $d^2 \geq 4df$, $\therefore d \geq 4f$.

$\therefore$ The least possible distance between object and image $d_L = 4f$. (5)

(c) - One lens should be concave, and the other convex.

- The lenses should be of different materials.
- The dispersion caused by the concave lens should be completely cancelled by the convex lens. (or the ratios of their focal lengths should be directly proportional to the ratios of the dispersive powers of their materials. (3)

i.e. $\frac{f_1}{f_2} = -\frac{\omega_1}{\omega_2}$).

- The radii of curvature of the concave and convex lenses should be numerically equal.

(d) (i) Action of the objective,

$$\frac{1}{V_o} = \frac{1}{f_o} - \frac{1}{u_o}$$

$$= \frac{1}{1} - \frac{1}{1.1}$$

$$V_o = 11.0 \text{ cm}.$$

Action of the eye piece,

$$\frac{1}{u_e} = \frac{1}{f_e} - \frac{1}{V_e}$$

$$= \frac{1}{5} + \frac{1}{30}$$

$$u_e = 4.3 \text{ cm}.$$

Lens separation

$$= u_e + V_o$$

$$= 4.3 + 11.0$$

$$= 15.3 \text{ cm}.$$

(3)

(ii) $M = \left(\frac{V_e}{f_e} - 1\right)\left(\frac{V_o}{f_o} - 1\right)\frac{D}{V_e}$

$= \left(\frac{-30}{5} - 1\right)\left(\frac{11}{1.0} - 1\right)\frac{25}{(-30)}$ (3)

$= \underline{5.8}$ 583

$M = \frac{h_1}{u_e}\frac{D}{h} = \left(\frac{h_1}{h}\right)\frac{D}{u_e} = \left(\frac{v_o}{f_o} - 1\right)\frac{D}{u_e} = \left(\frac{11}{1.0} - 1\right)\left(\frac{25}{-5}\right)$

$= 58.$

(e)

Compound microscope	Astronomical telescope
- ~~Obje~~ Focal length of objective lens is smaller than of eye piece	Focal length of objective is bigger than that of the eye piece.
- In normal adjustment final image is formed at the near point	- In normal adjustment final image is formed at infinity.
- used to view near objects	- used to view distant objects.
- Has greater resolving power	- Has smaller resolving power.

tube filled with water. The level of water in the tube is gradual lowered until a loud sound is heard. The length of the air column in the tube is measured. The level is further lowered until a second loud sound is heard. The length of the air column is measured. The end correction e, is calculated from $e = \frac{l_2 - 3l_1}{2}$

(7)

3(a) (i) Resonance is the vibration of a body at its natural frequency due to impulses received from a nearby source vibrating at the same frequency. (1)

(ii) The fundamental frequency is the lowest frequency that a vibrating string or air in a pipe can produce. (1)

(b) A sounding tuning fork of frequency f is held at the mouth of a tube filled with water. The level of the water is gradually lowered until a loud sound is heard. The length l of the air column in the tube is measured. The procedure is repeated using tuning forks of different frequencies f. The results are recorded in a table including values of $\frac{1}{f}$. A graph of l against $\frac{1}{f}$ is plotted. The intercept c on the l-axis is noted, and is equal to the end correction. (5)

$te = \lambda/4$

$Te = \frac{\lambda}{4}$

$e = \frac{3(4Te)}{2}$

$\lambda/4 = 12$

$= \frac{l_2}{2}$

2(c) (i) $l = \frac{\lambda}{2} \Rightarrow \lambda = 2l = 2 \times 50 \times 10^{-2} = 1\,m$. (3)

$v = f\lambda = 15 \times 1 = 15\ ms^{-1}$

Now $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ where $\mu = \frac{\rho V}{l} = \rho A$.

$\Rightarrow f = \frac{1}{2l}\sqrt{\frac{T}{\rho A}} \Leftrightarrow 15 = \frac{1}{2 \times 50 \times 10^{-2}}\sqrt{\frac{T}{A \times 8000}}$ (3)

$\frac{T}{A} = (15 \times 2 \times 50 \times 10^{-2})^2 \times 8000 = 1.8 \times 10^6\ Nm^{-2}$

(d) (i) When two waves of nearly equal frequency and similar amplitudes are sounded together, they superpose. When they meet in phase, constructive interference takes place and a loud sound is heard (or obtained). When they meet completely out of phase, destructive interference takes place and soft sound is heard. A periodic rise and fall in intensity (or loudness) of sound is heard, which is called beats.

(ii) When two waves of the same frequency, equal wavelength and equal amplitude are propagating in the same medium in opposite directions, they meet and superpose. The resultant displacement of particles in the medium at any point is the sum of the displacements due to each of the waves at that point. At particular points, they meet in phase and the amplitude is maximum. These are antinodes. At some points, the waves meet antiphase and the amplitude is minimum (zero). These are nodes. The resultant wave is a stationary wave.

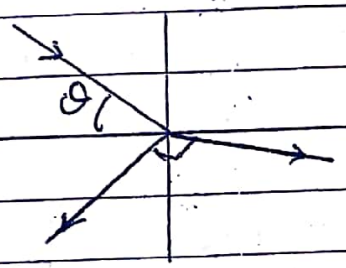
(a) (i) plane polarised light is one whose $\vec{E}$ vibrations are confined to one plane, to the direction of propagation of the wave. (1)

(ii) Sound waves are longitudinal, so its vibrations are parallel to the direction of propagation of the wave, thus it can not be polarised. (1)

(b) (i) Bright light will be viewed. (or no light will be viewed).
If the orientation of B is the same as of A, bright light is viewed, and even when rotated, the brightness remains the same. This is because the rotation of B does not change the orientation of B with respect to the plane of polarisation. &
(If the orientation of B is perpendicular to that of A, no light is viewed and the reason is the same as above). (3)

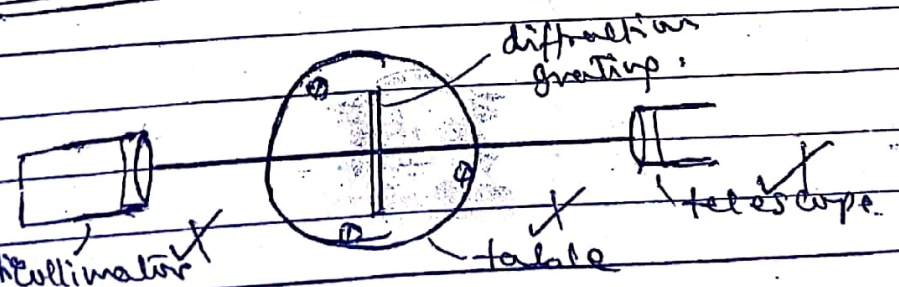
(ii) From Brewster's law

$$\tan\theta = n$$
$$= 1.55$$
$$\Rightarrow \theta = 57.2^\circ$$



(3)

(c)



- The telescope is adjusted to focus parallel light. The collimator is adjusted to produce parallel light, and the table is levelled.

The grating is placed on the table so that its plane is perpendicular to the incident light. The zero order image is now received by the telescope. This position T_1 on the scale is noted. The telescope is now turned in one direction until the first order image is obtained. The angle θ_1 of rotation from position T_1 is recorded. The telescope is restored to position T_1, and again rotated in the opposite direction until the first order image is again obtained. The angle θ_2 of rotation from T_1 is noted. (7

The wave length λ is now calculated from $\lambda = d \sin\left(\frac{\theta_1+\theta_2}{2}\right)$ where d is the spacing of the grating.

(d)(i) $d = \frac{1}{600} = 1.67\times10^{-3}$ mm $= 1.67\times10^{-6}$ m.

now $\frac{d}{\lambda} = \frac{1.67\times10^{-6}}{650\times10^{-9}} = 2.57$.

$\therefore$ The highest order is 2. (3

$\Rightarrow$ The total no. of images is 5.

(ii) $\sin\theta = \frac{m\lambda}{d} = \frac{2\times650\times10^{-9}}{1.67\times10^{-6}}$

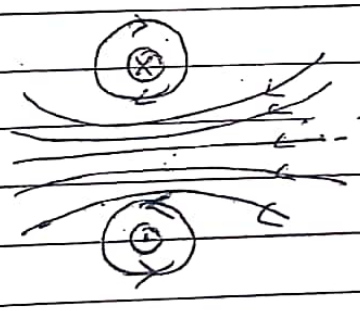
$\therefore \theta = 51.1°$ or $51.3°$ (2

5 (a) (i) The Weber is the magnetic flux that passes normally through an area of $1\,m^2$ when the magnetic flux density is 1T. (1)

(ii) The ampere is the steady current which when flowing in each of two infinitely long straight, parallel, conductors of negligible cross sectional areas and are 1m apart in vacuum, causes each conductor to exert a force of 2.0×10^{-7} N per meter of length on the other wire. (1)

(b) (i) $B = \frac{\mu N I}{2R}$ where μ is the permeability of the medium. (1)

(ii)



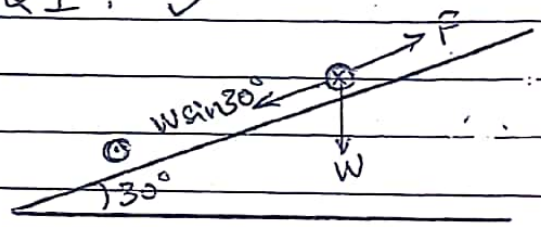
- directions of current.
- direction of magnetic field lines
- pattern. (2)

(c) The circular coil is set with its plane in the magnetic meridian of the earth. A deflection magnetometer is mounted at a vertical axis at the centre of the circular coil, with its pointers initially at the zero marks. The coil is then connected through a reversing switch to a battery, rheostat and an ammeter. The rheostat is adjusted so that the ammeter

reads a suitable value of current, I. The deflections θ_1 and θ_2 are noted. The current in the coil is reversed, and the new deflections θ_3 and θ_4 are noted. The procedure is repeated for other suitable values of I. The results are recorded in a table, including values of $\theta = \frac{\theta_1+\theta_2+\theta_3+\theta_4}{4}$, and $\tan\theta$.

A graph of $\tan\theta$ against I is plotted, and it is linear showing that $\tan\theta \propto I$. Since $B = B_H \tan\theta$, where B_H is the horizontal component of the earth's magnetic flux density $\Rightarrow B \propto I$.

(d) (i)



Force between the two wires

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi a}$$

$$= \frac{4\pi \times 10^{-7} \times 10 \times 1 \times 0.2}{2\pi \times 0.04}$$

$$= 1.0 \times 10^{-5} N$$

But $F = W \sin 30°$

$$\therefore W = \frac{F}{\sin 30°} = \frac{1.0 \times 10^{-5}}{\sin 30°} = 2.0 \times 10^{-5} N$$

(e) (i) When the oscillation in the ballistic galvanometer is damped, the deflection is not proportional to charge. (1)

- to increase the sensitivity of the galvanometer.
- obtain a large deflection.

(ii) Damping in the galvanometer can be reduced by:-

- winding the coil on a non-conducting material.
- making the coil heavy, for large inertia. (3)
- making the suspension fine so as to increase the period of oscillation of the coil.

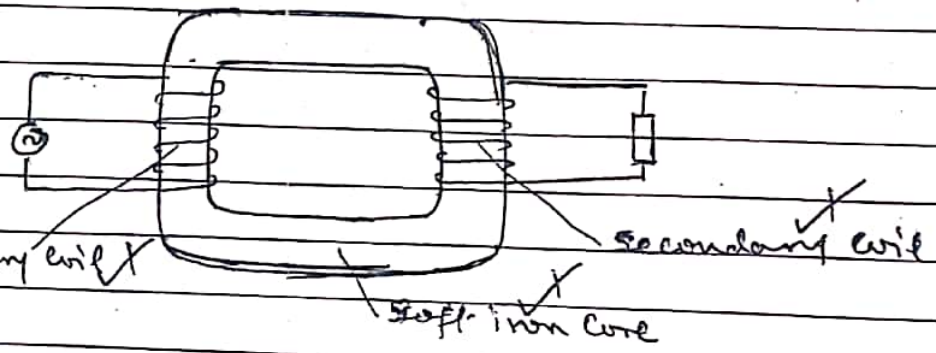
(13)

6(a)(i) Self induction is the production of emf in a coil or circuit when the current flowing through the same coil changes.

- mutual induction is the production of emf in a coil or circuit when the current flowing in a neighbouring coil changes.

(ii) Faraday's law of electromagnetic induction states that the magnitude of emf induced in a conductor is directly proportional to the rate of change of magnetic flux linked with the coil.

(b)(i)



An alternating voltage connected to the primary coil produces an alternating current in it. This sets up an alternating magnetic flux in the core which links up the secondary coil and thus induces an alternating emf V_s in the secondary coil. The magnitude of the emf induced in the secondary coil is $V_s = N_s A \frac{dB}{dt}$ — (1)

The changing magnetic flux also links the primary and induces a back emf in the same coil whose magnitude $V_p = -N_p A \frac{dB}{dt}$ — (2)

Can be awarded on the statement

Thus $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

When $N_s > N_p$, $V_s > V_p$ and the transformer is a step up transformer. When $N_s < N_p$, $V_s < V_p$, and it is a step down transformer. (6).

(ii) The cables that transmit power, have resistance and therefore power is lost due to production of heat in the cables as current flows through them. power loss $P = I^2R$. To reduce power loss, current supplied must be small. Now power $P = IV \Rightarrow I = \frac{P}{V}$, hence for current to be small, voltage must be high. (3)

b) (i) As the rod PQ moves, it cuts the magnetic field and an emf is induced across it. Since the rod is in a closed circuit, induced current flows through it. By Fleming's left hand rule, magnetic force acts on the rod in such a way as to oppose the motion. If PQ moves with constant velocity, then the magnetic force acting is equal to the force F responsible for the motion. (3)

(ii) $E = Blv$
$= 1.5 \times 20 \times 10^{-3} \times 6$ (2)
$= 0.18\,V$

(iii) $F = BIl = B \times \frac{E}{R} \times l$
$= 1.5 \times \frac{0.18}{4} \times 20 \times 10^{-3}$
$= 1.35 \times 10^{-3}\,N$ (3)

Transmission is at high voltage to reduce power loss. Power supplied $P = IV \Leftrightarrow I = \frac{P}{V}$, hence when V is high I is small [illegible]

7(a) - Peak value of an alternating current is the maximum value of the a.c.
- Root mean square value of a.c. is that steady current which produces the same heating effect per second in a given resistor as the a.c.

(b) When switch K is closed, current begins to flow through the coil and the changing magnetic flux due to the change in current induces a back emf in the coil which opposes the growth of current through the coil, thus most of the current flows through the bulb making it light brighter. In a short time the back emf reduces to zero and all the current flows through the coil hence the bulb stops lighting.

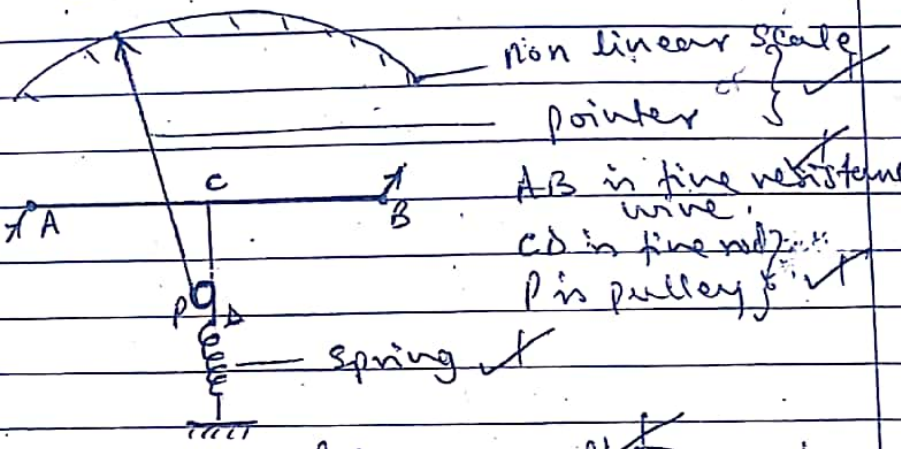
(c) (i) $X_L = 2\pi f L$
$= 2 \times 3.14 \times 60 \times 0.2$ (3)
$= 75.36\ \Omega$

(ii) $I_{rms} = \frac{V_{rms}}{X_L}$
$= \frac{20}{75.36}$
$= 0.27\ A$

(iii) In the first quarter cycle when the current is increasing, work is done against back emf. The energy is supplied by the source and stored in the magnetic field of the coil. In the 2nd quarter cycle, as current begins to reduce, the magnetic field begins

to collapse and energy is now being returned to the source. In the third quarter cycle energy is again transferred from the source to the coil and in the fourth quarter cycle energy is returned to the source. In one cycle the energy supplied to the coil is zero. (3)

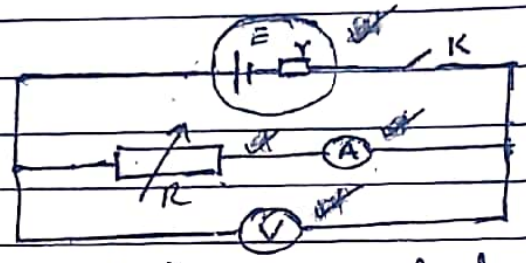
d)



Current to be measured is passed through the fine resistance wire AB. The wire heats up, expands, and sags. The sag is taken up by the fine rod CD, which passes round a pulley P attached to the pointer. The pulley rotates and causes the pointer to rotate over the scale. The deflection is proportional to the sag, and is therefore proportional to the square of the average current.

3(a) Electromotive force is the energy supplied by a cell to drive one Coulomb of charge around a complete circuit in which the cell is connected. (1)

(b)



for correct diagram

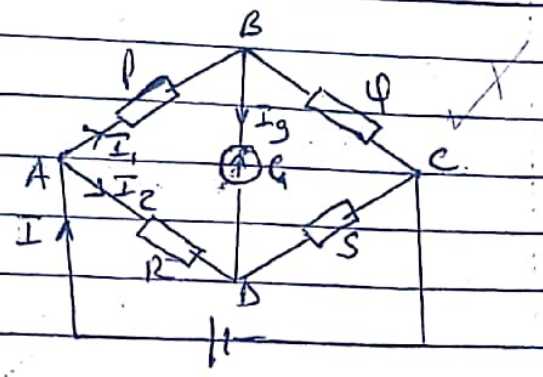
R – is a resistance box or rheostat.

The circuit is connected as above. Switch K is closed, and R adjusted to a suitable value of I. The values of I and V are recorded. More values of I and V are obtained with different settings of R.
A graph of V against I is plotted. The intercept on the V axis is noted, which is the emf of the cell. The slope, S, is obtained, and the internal resistance of the cell $r = -S$. (5)

(c) (i) Temperature coefficient of resistance is the fractional change in resistance ~~of~~ 0°c ~~for~~ every degree Celsius rise in temperature. (1)
or kelvin

(ii) When current is passed through a thermister heat is generated. As the temperature increases, the loosely bound electrons are released for conduction. Thus current increases, implying that resistance reduces. (2)

1) (i)



The resistances P, Q, R and S are adjusted so that $I_g = 0$. This implies that the potential at B is equal to the potential at D. Hence

p.d. across P = p.d. across R

$I_1 P = I_2 R$ — (1).

Current flowing through Q is therefore I_1 and that through S is I_2.

p.d. across Q = p.d. across S

$I_1 Q = I_2 S$ — (2). (4)

Hence (1)/(2) $\frac{P}{Q} = \frac{R}{S}$

(ii) – This is when the test resistance is either too low or too high in comparison to the other resistances used.

– In the above diagram for example if R and S are the resistances to be compared and R is very large, then more current flows through S than R implying that $I_g \neq 0$. The same when S is very large compared to R, $I_g \neq 0$. (2)

margin

(e) From $\frac{R_\theta}{R_S} = \frac{l_1}{l_2}$

When At $\theta = 0$ $R_S = 10\,\Omega$, $\frac{R_\theta}{10} = \frac{40}{60} \Rightarrow R_0 = 6.67\,\Omega$

At $\theta = 100$ $\frac{R_{100}}{10} = \frac{50}{50} \Rightarrow R_{100} = 10.0\,\Omega$

From $\alpha = \frac{R_{100} - R_0}{R_0 \theta} = \frac{10 - 6.67}{6.67 \times 100} = 4.99 \times 10^{-3}\,K^{-1}$

When $l_1 = 42\,cm$, $l_2 = 58\,cm$.

$\therefore \frac{R_\theta}{10} = \frac{42}{58} \Rightarrow R_\theta = 7.24\,\Omega$.

$\therefore \theta = \frac{R_\theta - R_0}{R_0 \alpha} = \frac{7.24 - 6.67}{6.67 \times 4.99 \times 10^{-3}}$

$= 17.1\,^\circ C$

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(21)

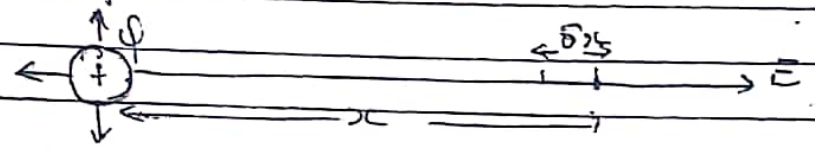
(a)(i) Electric field intensity is the force acting on 1C of positive charge placed at a point in an electric field. (1)

(ii) A metal can placed on an insulator is connected to the cap of a neutral gold leaf electroscope. Proof planes that fit different parts of the charged conductor are pressed on the corresponding parts of the conductor and then lowered one at a time into the can. The deflection of the gold leaf electroscope for each case is noted. It is found that the deflection is greatest for the proof plane pressed at the sharpest point on the conductor. Hence charge concentration is greatest at the sharpest point. (4)

(iii) When a negatively charged cloud passes over a building with lightning conductor, it induces positive or opposite charge on the spikes of the conductor and repels electrons or opposite charge to earth. The high concentration of charge at the spikes leads to high electric field intensity around the spikes. This ionises air molecules around the spikes. Negative ions are attracted to the spikes and neutralised, while positive ions are repelled towards the cloud where it is neutralised. Hence the house is protected. (4)

(b) (i) Electric field line is the path (or direction) taken by a small positive charge placed in the field. (1)

(ii)



Consider a charge of +1C placed a distance x from the fixed charge in air.

Force acting on the 1C charge is

$$F = \frac{KQ \times 1}{x^2}$$

If the 1C charge is displaced distance δx towards the fixed charge, the work done,

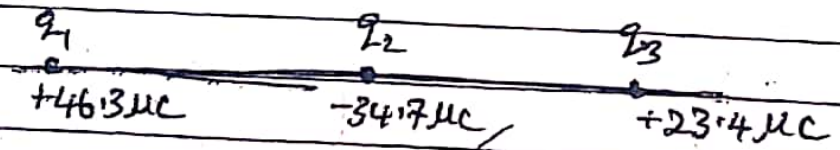
$$\delta W = F(-\delta x).$$

Total work done to bring +1C charge from infinity to a point, distance a from the fixed charge, $W = \int_{\infty}^{a} -F\,dx = \int_{\infty}^{a} -\frac{KQ}{x^2}\,dx$ (4)

$$= \left[\frac{KQ}{a}\right]_{\infty}^{a} = \frac{Q}{4\pi\varepsilon_0 a}$$

where ε_0 is permittivity of air.

c)



$$F = \frac{KQ_1Q_2}{r^2}$$

$$F_1 = \frac{9\times10^9 \times 46.3\times10^{-6} \times 23.4\times10^{-6}}{(0.3)^2} =$$

$= 108.3 \times 10^{-3}$ N ✓

$$F_2 = \frac{9 \times 10^9 \times (-34.7) \times 10^{-6} \times 23.4 \times 10^{-6}}{(0.1)^2}$$ ✓

$= -730.8 \times 10^{-3}$ N ✓

The resultant force $F = F_1 + F_2$

$= (108.3 - 730.8) \times 10^{-3}$ N

$= -0.622$ N ✓ -0.6225 N ✓

Penalise ½ if without direction of force
without units with correct value

The force is to the left or attractive ✓

(2)

(6)

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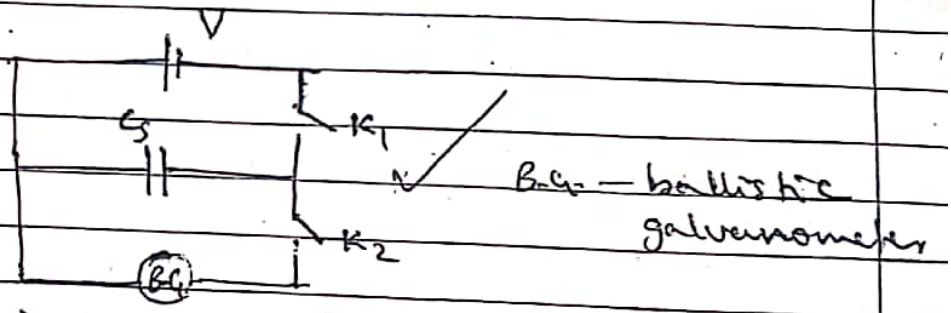
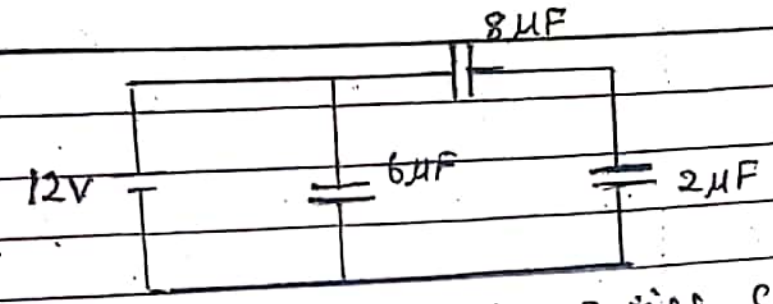
10(a) (i) The farad is the capacitance of a capacitor (or conductor) which when a charge of 1C is stored on it, the p.d. between its plates is 1V. (1)

(ii) Relative permittivity is the ratio of capacitance of a capacitor with the dielectric between its plates to the capacitance of the same capacitor when the space between its plates is vacuum. (OR the ratio of permittivity of the material to the permittivity of free space). (1)

(b)



The circuit is connected as above. First with standard capacitor of capacitance C_s switch K_1 is closed and after a short time it is opened. Switch K_2 is now closed and the deflection of the B.G. θ_s is noted. The capacitor is replaced with the test capacitor and the procedure repeated. The deflection θ of the B.G. is noted. Capacitance C of the test capacitor is now calculated from $C = \frac{\theta}{\theta_s} \cdot C_s$ (5)



(i) Effective capacitance in series C' is given by

$$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{8} + \frac{1}{2}$$

$$\Rightarrow \quad C' = 1.6\,\mu F$$

C_3 and C' are in parallel; effective capacitance $C = C_3 + C'$

$$= 6 + 1.6 = 7.6\,\mu F.$$

(4)

Total energy stored in the capacitor,

$$E = \frac{1}{2} C V^2 = \frac{1}{2} \times 7.6 \times 10^{-6} \times 12^2$$

$$= 5.47 \times 10^{-4}\,J$$

(ii) Capacitance $C_2' = \varepsilon_r C_2$

$$= \frac{5}{4} \times 2 = 2.5 \times 10^{-6}\,F.$$

Equivalent capacitance of C_1 and C_2'

$$= \frac{8 \times 2.5}{8 + 2.5} = 1.9\,\mu F$$

Effective capacitance $C = 6 + 1.9\,\mu F$

$$= 7.9\,\mu F$$

(4)

$\therefore$ New total energy $E = \frac{1}{2} \times 7.9 \times 10^{-6} \times 12^2$

$$= 5.69 \times 10^{-4}\,J$$

26

(d) Capacitance $C = \frac{\varepsilon A}{d}$, when d is increased, C reduces.
Also $V = \frac{Q}{C}$ where Q is the charge, and since charge remains constant.
V increases when C reduces.

(e) Electrons flow from the negative plate to the positive plate until the plates are completely neutralised (charges neutralised) or the P.d. between the plates is zero)

10(d) Electric field intensity E between plates of the capacitor. $E = -\frac{V}{d} \Rightarrow V = -dE$
Since E is constant $V \propto d$
Therefore when the separation is increased the p.d increases

10(d) When the plates of a capacitor are being pulled apart, work is done against the electrostatic attraction.
This work is stored as electrostatic potential.
Therefore as the separation between the plates increases the p.d increases