CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)
NORTHEN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)

FORM FOUR PRE-NATIONAL EXAMINATIONS AUGUST 2024

PHYSICS 1

MARKING SCHEME

SECTION A

1.

I	ii	iii	iv	V	vi	vii	viii	ix	x
D	D	D	D	A	C	C	E	D	A

10 Marks @ 01 mark

2.

I	ii	Iii	iv	v
C	E	G	I	H

06 Marks @ 01 mark

SECTION B

3. (a) Given

Focal length, f= 12cm

Object distance,u=30cm

Height of object, h_0 =3cm

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

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$= \frac{1}{12} - \frac{1}{30}$$

$$= \frac{5-2}{60}$$

$$= \frac{3}{60}$$

$$v = \frac{60}{3}$$

= 20cm

Since the image distance is positive, the image is real.

Magnification

$$m = -\frac{v}{u}$$

$$= \frac{h_i}{h_0}$$

$$\frac{h_i}{3} = -\frac{20}{30}$$

$$h_i = -2cm$$

(b) Required to show : $u = \frac{M+1}{M}f$.

From $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ and $M = \frac{v}{u}$

$$\frac{1}{f} = \frac{u+v}{vu}$$

$$vu = f(u+v)$$

$$vu = fu + fv$$

$$vu - fv = fu$$

$$\frac{vu-fv}{f} = u$$

$$\frac{v(u-f)}{f} = u$$

But $v = mu$

$$\frac{mu(u-f)}{f} = u$$

$$\frac{mu^2-muf}{f} = u$$

$$\frac{mu-mf}{f} = 1$$

$$mu - mf = f$$

$$mu = mf + f$$

$$u = \frac{mf+f}{m}$$

$u = \frac{(m+1)}{m}f$ shown

4. (a) (i) Given

Mass of bullet, $m_b = 10g(0.01kg)$

Mass of wood, $m_w = 390g\ (0.39kg)$

Final velocity of wood, $v_w = 10m/s$

Initial velocity of bullet, u_b =?

From the principle of conservation of linear momentum

Momentum before collision=Momentum after collision

$$m_b u_b + m_w u_w = (m_b + m_w)v$$

But $u_w = 0$

$$m_b u_b = 10(0.01 + 0.39)$$

$$0.01u_b = 4$$

$$u_b = \frac{4}{0.01}$$

$$u_b = 400m/s$$

(ii) Kinetic energy before collision,

$$kinetic\ energy\ \ before\ collision = \frac{1}{2}m_b {u_b}^2 + \frac{1}{2}m_w {u_w}^2$$

$$= \frac{1}{2} \times 0.01 \times (400)^2$$

$$= 800J$$

Kinetic energy after collision, $KE\ after\ collision = \frac{1}{2}(m_b + m_w){v_w}^2$

$$= \frac{1}{2}(0.01 + 0.39)\ (10^2)$$

$$= 20J$$

(b) (i) Given

Maximum height, H=20m

Final velocity, $v = 0$

Initial velocity, u=?

From $v^2 = u^2 - 2gH$

$$0 = u^2 - 2gH$$

$$u^2 = 2gH$$

$$= 2 \times 10 \times 20$$

$$= 400$$

$$u = \sqrt{400}$$

$$u = 20m/s$$

(ii) Time taken to reach the maximum height

$v = u - gt$

$0 = 20 - 10t$

$20 = 10t$

$t = \frac{20}{10}$

$t = 2sec$

5. (a) Given

Mass of brass cylinder, $= x$

Initial temperature of brass cylinder, $\theta_b = 100°C$

Specific heat capacity of brass cylinder $c_b = 320jkg^{-1}k^{-1}$

Mass of paraffin $m_p = 150g$

Initial temperature of paraffin $\theta_p = 11°C$

Final temperature of paraffin $\theta = 20°C$

Specific heat capacity of paraffin $c_p = 2200jkg^{-1}k^{-1}$

Then

Heat lost by brass cylinder = Heat gained by paraffin

$m_b c_b \Delta T = m_p c_p \Delta T$

$x \times 320 \times (100°C - 20°C) = 0.15 \times 2200 \times (20°C - 11°C)$

$x \times 320 \times 80°C = 0.15 \times 2200 \times 9°C$

$x = \frac{2970}{25600}$

$x = 0.12kg$

(b) Given

Initial temperature of an iron plate $\theta = 20°C$

Initial radius, $r_1 = 8.92mm$

Final radius, r_2=8.95mm

Change in temperature, $\Delta\theta =?$

From the expression for linear expansivity,

$\Delta\theta = \frac{r_2 - r_1}{\alpha r_1}$

$= \frac{8.95 - 8.92}{1.02 \times 10^{-5} \times 8.92}$

$= 329.7K$

Final temperature is

$\theta_f = (293 + 329.7)K$

$= 622.7K$

Or

$\theta_f = 20°C + 329.7°C$

$= 349.7°C$.

This is the temperature at which the iron plate must be heated.

6. (a) From Newton's second law of motion

$$F \propto \ change\ of\ momentum$$

$$F = k\ \times change\ of\ momentum$$

$$F = k\frac{mv-mu}{t}$$

$$F = k\frac{m(v-u)}{t}$$

But $\frac{(v-u)}{t} = a$

$$F = kma$$

But k=1

$$F = ma$$

Therefore a unit force can be defined as the product of a unit mass and unit acceleration.

(b) Given

Handle of screw jack, r=35cm

Pitch of screw jack, p=0.5cm

Efficiency of the screw jack e,=55%

Load, l = $2300N$

Force, F= ?

Then

$$e = \frac{MA}{VR} \times 100\%$$

$$VR = \frac{2\pi r}{P}$$

$$= \frac{2\times\pi\times35}{0.5}$$

$$= \frac{219.8}{0.5}$$

$$= 439.6$$

Then

$$e = \frac{MA}{VR} \times 100\%$$

$$55\% = \frac{MA}{439.6} \times 100\%$$

$$MA = \frac{55\times439.6}{100}$$

$$MA = 241.78$$

Then

$$MA = \frac{Load}{Effort}$$

$$Effort = \frac{Load}{MA}$$

$$Effort = \frac{2300N}{241.78}$$

$$Effort = 9.51N$$

7. (a) It means that after 64 days the half of the element will remain undecayed.

(b) Different isotopes will differ at least by 1 $neutron$. That is

$A_1 = 108, A_2 = 109, A_3 = 110 \dots A_n$

Since there are 25 $isotopes, n = 25$

From arithmetic progression,

$A_n = A_1 + (n-1)d$

In this case, $A_1 = 108,\ n = 25, d = 1$

$A_n = 108\ + (25-1)1$

$A_n = 132$

Hence the heaviest isotope of tin will be ${}^{132}_{50}S_n$

8. (a) Effects of global warming

(i) Rise in temperature

(ii) Rise in sea level

(iii) Change in worlds climatic pattern

(iv) Acidification of the oceans

(b) data

Current I_1= 3A

Resistance R1= 5Ω

Current I_2 = 0.25A

Resistance R2 = 4Ω

From

Emf_1 = I(R +r)

E_1 = 3(5+r)

E_1= 15+r……………………………. (i)

Then

$E_2 = I_2 (R_2 + r)$

$E_2 = 0.25(4+r)$

$E_2 = 1 + 0.25r$……………………. (ii)

But $E_1 = E_2$

$15+r = 1 + 0.25r$

$r = -5.09\Omega$

Emf $= I(R+r)$

$= 3(5-5.09)$

Emf = - 0.27V

SECTION C

9. (a) (i) Beat is the regular rising and falling of sound of two notes of nearly equal frequency when sounded together.

(ii) Beats occur when two notes of nearly equal frequency when sounded together.

(b) Given

Distance between first man and the cliff = $510m$

Time interval between original sound and echo $= 1.0s$

Distance between two men =X

Velocity of sound in air,$v = 340m/s$

Then

$v = \frac{2S}{t}$ ---(i)

$340 = \frac{2\times(510-x)}{1.0}$ --------------------------------------(ii)

$x = 340m$

Distance between two men is $340m$

(c) Given

$I_p = 5A$

$N_s = 10000\ turns$

$N_P = 100\ turns$

$V_P = 12V$

$V_S = ?$

$I_S = ?$

(i) $\frac{N_S}{N_p} = \frac{V_S}{V_p} = \frac{I_P}{I_S}$

Using the segment $\frac{N_S}{N_p} = \frac{V_S}{V_p}$

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

$$V_s = \frac{10000}{100} \times 12$$

$$V_s = \quad 1200V$$

Voltage across the secondary coil is 1200V

(ii) Power in primary $P_p = I_p V_P$

Then

$$P_p = I_p V_p$$
$$P_p = 5.0 \times 120$$
$$P_p = 60W$$

Power in secondary (P_p) =$I_s = V_s$

Then

Efficiency = $\frac{I_s V_s}{P_p} \times 100\%$

$$I_s = \frac{efficiency \times P_p}{V_s \times 100\%}$$

$$I_s = \frac{90\% \times 60W}{1200 \times 100\%}$$

$$I_s = 0.045A$$

∴ The magnitude of secondary current is $0.045A$

10. (a) Bipolar transistors require a biasing input current at their control leads and require both positive and negative charge carriers to operate. While Field effect transistors require only voltage and one charge carrier to operate.

(b) (i) (1) **Effect of temperature on conductors**

With the increase in temperature, the electrical resistance of metals increases, an increase in resistance is due to increased vibrations of atoms with the increase in temperature, leading to increased collisions between the vibrating atoms and the moving electrons. So, despite having greater kinetic energy at higher temperature, the electrons face much more hindrance in their path from the vibrating atoms. This hindrance in the motion of electrons is the reason for the increased resistivity of the conductor, and hence decreased conductivity.

(2) **Effects of temperature on the conductivity of semiconductors**

An increase in temperature of the semiconductor material increases the amount of conduction electrons and hence its conductivity.

(3) Effects of temperature on the conductivity of insulators

For insulators the conductivity is increased when the temperature is increased from absolute zero.

(ii) (1) **Conductors**

Are materials that have high electrical conductivity. In terms of the band theory , in conductors the valence band overlaps the conduction band with the Fermi level lying in the conduction band. That is, there is no forbidden band gap between the two. Due to this overlapping, many free electrons are also available in the conduction band and they are responsible for the conduction of electric current.

(2) **Insulators**

Are materials that do not conduct electric current. Considering the band theory, the valence band of insulators is full, whereas the conduction band is empty and the forbidden band is very large.

(3) **Semiconductors**

Are materials whose electrical conductivities lie between those of conductors and insulators. In their pure state, the semiconductors are neither conductors nor insulators, and under certain conditions, they can conduct current electricity. In terms of energy band semiconductors have a small forbidden energy gap between the valence and conduction band.

(iii) The current, I_E is obtained from the relation $I_E = I_B + I_C$

But I_C Can be obtained from the relation

$$\beta = \frac{I_C}{I_B}$$

Therefore

$$I_C = \beta I_B$$

$$= 50 \times 20 \times 10^{-6}$$

$$= 1 \times 10^{-3} A$$

$$= 1 mA$$

Using the relation,

$$I_E = I_C + I_B$$

$$= 1mA + 0.02mA$$

$$= 1.02mA$$

$$I_E = 1.02mA$$

11. (a) (i) (1) Nature of the liquid

The rate of evaporation depends upon the nature of the liquid. Some liquids evaporate more quickly compared to others. Liquids that have low boiling point, evaporate in short period of time at ordinary temperature.

(2) Temperature

The ability of an air to hold water vapour depends on its temperature. As the air temperature increases, the capacity of air to hold water vapour increases too.

(3) Surface area

It takes shorter time for unfolded to dry than the folded one.

(4) Wind

The rate of flow of air determines the rate of evaporation into the surrounding air. In a windy environment the rate of evaporation is high.

(5) Amount of water vapour in air

The more humid the air, the lower the rate of evaporation.

(ii) When air is warm, the molecules have more energy and they move about creating space for more water vapor molecules to fill in.

(b) $R_H = \frac{Actual\ vapour\ density}{absolute\ humidity} \times 100\%$

Actual water vapour density

$= R_H \times Absolute\ humidity$

$= \frac{53.6}{100} \times 23.05 g/m^3$

$= 12.35 g/m^3$

Therefore, actual water vapour density $= 12.35 g/m^3$

(c) (i) The particles of gas move randomly in all directions at high speed. As a result, the particles hit each other and also hit the walls of the container with force.

(ii) $R_H = \frac{S.V.P\ at\ dew\ point\ T_1}{S.V.P\ at\ temperature\ of\ the\ air\ T_2} \times 100\%$

$= \frac{6.7mmHg}{14mmHg} \times 100\%$

$= 48\%$

Therefore, the relative humidity 48% .