CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)

NORTHERN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)

FORM SIX PRE-NATIONAL EXAMINATION 2023

PHYSICS 1

MARKING SCHEME

1 (a) (i) this is not dimensionally true

Momentum /volume =mass x velocity/volume $=MLT^{-1}/L^3 = ML^{-2}T^{-1}$

Pressure =Force/Area $=MLT^{-2}/L^2 = ML^{-1}T^{-2}$ (3Marks)

(ii) Principle of homogeneity state that "An equation is dimensionally if the dimension of the fundamental quantities (Mass, Length, and Time) are the same in each term on either side of the equation" (2marks)

(b) From $M=I^2RT$

$\Delta H/H=2\Delta I/I + \Delta R/R + +\Delta t/t$

Maximum percentage in measuring heat = $2+\Delta I/I$ X100 + $\Delta R/R$ X100 $+\Delta t/t$ x100

= 2(2%) + 1% + 1% =6 5marks

2 (a) (i) You can not shield a body from the gravitational influence of nearly matter by any means it is because the gravitational force on a body due to near by matter is not altered due to the presence of other bodies (2marks)

(ii) Weight of a body W =mg 63N, h =R/2 the value of acceleration due to gravity (g) at height h is $g' = gR^2/(R+H)^2 = GR^2/(R+R/2)^2 = 4/9g$ Gravitational force on the at5 height h is

$g = mg' = m \times 4/9g = 4/9 \times mg = 4/9 \times 63 = 28$ (3marks)

(b) Data given

$V = 5km/s$, $M = 6 \times 10^{24}kg$ $R = 6 \times 10^6 m$

According to the principle of conservation of energy , (K.E + P.E) at earth = (K.E + P.E) at height "h"

$1/2MV^2 - GMm/R = 0 + (-GMm/R + H)$ since K.E =0,

$V^2 - 2GM/R = 2GM/R + H$ $2GM/R + H = 2GM/R - V^2 = 2GM - V^2R/R$

$R + H = 2GMR/2GM - V^2R = 2X(6.67X10^{-11}) X(6X10^{24})X(6.4X10^6)$

$2X6.67X10^{-11}X6X10^{24}X(5000)^2X6.4X10^{6s}$

$= 8X10^6m$, $h = 8x10^6m - R$, $h = 8x10^6 - 6.4x10^6$

$h = 1.6x10^6m$ (5marks)

3 (a) (i) The rolling friction is less than the sliding friction. The wheels are made circular to convert sliding friction in to rolling friction (2marks)

(ii) r = 200m, v = 300km/h = 36 x 1000/60 x 60 =10m/s

let θ be the angle of banking then

$\tan\theta = V^2/rg = 10^2/200x9.8 = 0.051$, $\theta = \tan^{-1}(0.051)$ $\theta = 2.92°$ (3marks)

(b) The value of "g" at point Q, $g = GM./R^2$, But $M = 4/3(\Pi R^3\rho)/R^2$ $g = 4/3(\pi RG\rho)$……………….(i)eqn

$M' = 4/3\pi(R-d)^3\rho$

The value of "g" at point P "g" = $\frac{(4/3\pi(R-d)^3)\rho}{(R-d)^2}$

"g" $=4/3\pi(R-d)G\rho$……………………………………………(ii)eqn

Dividing eqn(i) by eqn(ii) "g"/g =(R-d)/R, g" = g(1 – d/R)

Hence shown (5marks)

4 (a) (i) $\theta = 45°$

Horizontal component , $V_X = V_O\cos\theta$, $V_X= V_O\cos45°$ $V_X = V_O\sqrt{2}$

The velocity at the highest point is $V_O\sqrt{2}$, (2marks)

(ii) $\theta = 45°$

$R_{max} = V_O^2\sin2\theta/g$, $V_O^2\sin(2x45°)/g$, $= V_O^2/g$

$H_{max} = V_O^2\sin2\theta/2g == V_O^2\sin45°/2g = V_O^2/4g$

Then $R_{MAX}/H_{MAX} = 4$ So $R_{MAX} = 4H_{MAX}$ (3marks)

(b) $V_f - V_i = V_{rel}\ln(M_i/M_f)$, $V_f = V_i + V_{rel}\ln(M_i/M_f)$,

$V_f = 3x\ 10^3m/s + 5x10^3m/s\ x\ \ln(M_i/M_ix0.5)$,

$V_f = 6465.7m/$

The speed of the rocket relative to the earth is = 6465.7m/s (3marks)

Thrust , $F = V_{rel}d_m/d_t$ $F = 5x10^3m/s\ x0.77kg/s$ The thrust in the rocket is

F = 3850N (2marks)

5 (a) (i) When a gas is heated at constant volume no work is done so that all the heat goes into increasing the internal energy and hence the temperature of the gas however when a gas is heated at constant pressure it expands and does work so that only a part of the heat is used to increase the

internal energy and temperature therefore it takes more heat at constant pressure than at constant volume for a given increase in temperature in othe r words is greater than C_V (2marks)

(ii) The heat gained by the boiler is utilized in vaporizing water

$Q = ML_V$......................................(i) Also

$$Q/t = \frac{KA(\theta_1 - \theta_2)}{X}$$

$$Q = t\,\frac{KA(\theta_1 - \theta_2)}{X} \qquad \text{......................................(ii)}$$

Equating the two equations

$t\,KA = KA(\theta_1 - \theta_2)/X$

$\theta_1 - \theta_2 = ML_V/\,t\,KA$, $\theta_2 = 100°C$ temp of the steam

$\theta_1 = ML_V/\,t\,KA, + \theta_2$, $\theta_1 = \frac{6kg \times 2256\times10^3 Jkg^{-1} x10^{-2}}{60s \times 109Js^{-1}°C^{-1} X\ 0.15m^2} + 100°C$

$\theta_1 = 237.98°C$ Therefore the temperature of the flame in contact with the boiler is

$\theta_1 = 237.98°C$ (3marks)

(b) (i) The Celsius temperature θ_g according to the gas scale

$\theta_g = (P_\theta - P_0/P_{100} - P_0) \times 100°C$

$$= \frac{1.528X10^5Pa - 1.333x10^5Pa}{1.821x10^5Pa - 1.333x10^5Pa} \times 100°C$$

$\theta_g = 39.64°C$ Therefore the temperature on the gas scale is about $\theta_g = 39.64°C$ (2.5marks)

(ii) The Celsius temperature θ_R according to the resistance scale

$\theta_R = (R_\theta - R_0/R_{100} - R_0) \times 100°C$

$$= \frac{34.59\Omega - 30\Omega}{41.58\Omega - 30\Omega} \times 100°C$$

$\theta_R = 39.64°C$ Therefore the temperature of the gas scale is about $= 39.64°C$ (2.5marks)

6(a) (i) Calorimetry is an experimental technique for the quantitative measurement of the heat exchange (1marks)

(ii) Power of kettle, P = 2.5kW = 2500W, Energy available per second = 2500J

$H = MC(\theta_2 - \theta_1) = 2500 \times 4.2 \times (100 - 25) = 63 \times 10^4 Js$

Time taken, from H/P = $63 \times 10^4 Js/2500J = 252$seconds

Let m be the grams of water at 100°C be evaporated intro steam in one seconds

= 2500J, = m x 2250J But the energy available in one second = 2500J/2250 = 1.11g

So m = 1.11g (4marks)

(b) From $C_V = C_P - R$, $C_V = 5R/2 - R$ $C_V = 3R/2$ If "m" is the mass of the gas in the vessel and M_r is the molecular mass of the gas, then, $PV = m/M_r RT$, then $m/M_r = PV/RT = 0.6X10^6 \times 0.083$

8.3 x 300 = 16/3

Let ΔT be the rise in temperature when m/M_r mole of gas is given , Heat energy at constant volume is $2.49 \times 10^4 J$ $Q = m/M_r C \Delta T$ then $\Delta T = Q/(m/M_r) \times C$ =

$2.49 \times 10^4 J$

(16/3) X (3/2) X 8.3 = 375K (2marks)

Now find the temperature of ga T' =300+275 = 675K

If P' is the final pressure of the gas then P'/T' = P/T then P' = P/T X T'

$= 1.6X10^6/300 \text{ X } 675K$ SO $P' = 3.6X10^6 N/M^2$ (2marks)

7(a) From $P = dE/dt = d/dt(1/2MV^2)$, $p = 1/2 (2MV dv/dt + V^2 dm/dt)$

For a constant wind speed dv/dt =0 Hence , $P = ½(V^2 dm/dt)$ if A is the crossectional area of the air column and density ρ is its density then the mass flow rate dm/dt =PAV

$P = 1/2PAV^3$ Hence shown (5marks)

7(b) The following are the disadvantage of the wind energy

(i) Requires expensive storage during peak production time
(ii) It is unreliable energy source as wind are uncertain and unpredictable
(iii) Requires large open areas for setting up wind farms
(iv) There is visual and authentic impact on region
(v) Noise pollution problem is usually associated with wind mills
(vi) Maintenance of wind turbines is costy
(vii) It can be threat to wild life (5marks 1©)

SECTION B (30 MARKS)

8(a)(i) The half portion of the wire on which cold water is not poured become hotter. It is because as cold water is poured, the resistance of cooled portion decreases and hence the current through the wire increases as a result the rate of production of heat ($P = I^2R$) increases. (2marks)

(ii) It is based on the law of conservation of energy (1mrk)

(b) (i) If area cross – section of metre bridge wire is not constant the resistance per unit length of the wire will be different over different length of the metre bridge wire. Therefore, the principle of potentiometer will not be obeyed. (2marks)

(ii) It is not necessary that the length of metre bridge should be 1m. since the wire forms two arms of Wheatstone bridge, any length of the wire can be used. (1mark)

(C)(i) Soln

(a) $X_c = 2\pi fc$

$= 2\pi \times 50 \times 25.48 \times 10^{-3}$

$= 8\Omega$

$X_c = \frac{1}{2\pi fc} = \frac{1}{2\pi \times 50} \times 796 \times 10^{-6} = 4\Omega$ (2marks)

Circuit impedance, $Z = \sqrt{R^2 + (X_L - X_c)^2}$

$= \sqrt{(3)^2 + (8 - 4)^2} = 5\Omega$

(b)Phase difference between circuit voltage and circuit current is

$I = \tan \frac{X_L - X_c}{R} = \tan \left(\frac{8 - 4}{3}\right)$

$= \tan (^4/_3)^3 = 53.1$ (2marks)

(c)Circuit current, $I_v = {}^{EV}/Z = \frac{E/\sqrt{2}}{Z} = \frac{283/\sqrt{2}}{5} = 40A$

Power dissipated in the circuit is

$P = I v^2 R = (40)^2 \times 3 = 4800W$ (3marks)

(d)Power factor = CosØ = cos 53.1 = 0.6 (2marks)

9(a) (i) Modulation is the process of changing some characteristics (eg Amplitude or frequency) of a carrier wave in accordance with the intensity of the signal While Demodulation is the process of extracting the information from a modulated carrier wave . (2marks)

(ii) ---- to get the desirable gain easily by controlling the external components

---- it improves the stability by minimizing the distortion

---- it improves the range of frequencies that the amplifier has to amplify (3marks)

(b) Given that $f_c = 2MHz$, $f_m = 4KHz$, $M = 0.55$ and $E_c = 70v$

(i) Lower sideband = $f_c - f_m = (2000 - 4)KHz = 1996KHz$

(ii) Upper sideband = $f_m + f_c = (4 + 2000)KHZ = 2004KHz$

(iii) Band width = upeer sideband – lower side band frequency
= 2004KHz – 1996KHz
= 8KHz

(iv) Amplitude = $ME_c/2$ = (0.55 x 70)/2 = 19.25v (5marks)

(c) (i) the collector current increases causing further heating of the transistor and so on until it is damaged or destroyed

(ii) ---- slight overloading of the transistor
---- increase in the surrounding temperature
---- replacement of one transistor by another of greater hF_E (5marks)

10 (a) (i) because most of the heat is produced at the collector junction. The collector is made larger to dissipate heat (2marks)

(ii) So that the diodes may not be damaged due to junction breakdown

(b) (i) $r_f = 20\Omega$, $R_L = 980\Omega$

Max a.c voltage, $V_m = 50 \times \sqrt{2} = 70.7v$

Max load current, $I_m = \frac{Vm}{rf+Rl} = \frac{70.7v}{(20+980)\Omega} = 70.7mA$

Mean load current, $I_{dc} = \frac{2Im}{\pi} = \frac{(2 \times 70.7)}{\pi} = 45mA$ (1.5marks)

R.m. s value 0f load current, $Irms = \frac{Im}{\sqrt{2}} = \frac{70}{\sqrt{2}} = 50mA$

R.m.s value of load current =50mA (1.5marks)

(ii) I_L = 4.0mA, V_Z = 6v E_{in} = 10.0v, R_s =?

$I_Z = 5I_L$ =5 X 4.0mA =20mA, Current through R_S, I = I_Z = I_L =(20 + 4)mA
= 24mA Voltage across R_S , $E_{in} – V_Z$ = 10.0v – 6.0v = 4v

R_S = Voltage across R_S /I =4v/24mA = 167Ω

The value of series resistor is 167Ω (5marks)

(c) (i) The intrinsic semiconductor is neutral and the atoms of the added pentavalent impurity are also neutral . Therefore n-type semiconductor is neutral (2marks)

(ii) $\rho = \frac{1}{ne(\mu e+ \mu h)}$

= $1/(2x10^{19} \times 1.6x10^{-19}) \times (0.36 + 0.17)$ =0.59Ωm

Resistance of thje germanium plate is

= R = $\rho\frac{I}{A}$ = $0.59 \times 0.3x10^{-3} /1x10^{-4}$ = 1.77Ω

Current I = V/R = 2/1.77 = 1.13A. (3marks)