2012 H2 Physics A Level Paper 2

1

(a) Hooke's Law is obeyed as the force on the spring is directly proportional to the extension of the spring. This can be seen from the graph which is a straight line and an x-intercept of the unstretched length of 12 cm.

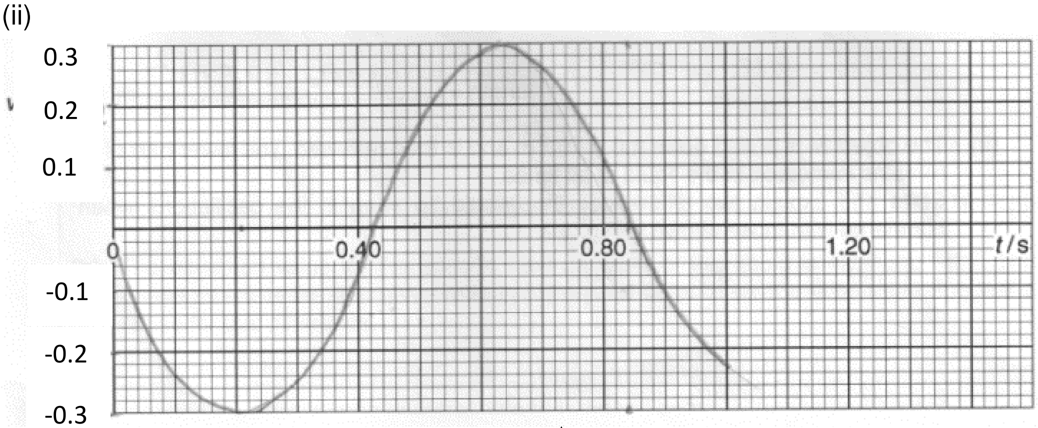
(b) Work done = Area under F-l graph = 0.5 × 1.4 × (30.0 – 12.0) × 10^{-2} = 0.126 J

(c) (i) As object is undergoing S.H.M,

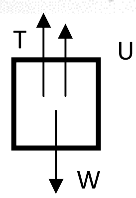
$$v_0 = \omega x_0$$
$$v_0 = (\frac{2\pi}{T}x_0)$$ (From graph, $x_0 = 43.0\times10^{-2} m$ and T = 0.084 s)
$$v_0 = 0.299 \text{ m s}^{-1}$$

Alternatively, the gradient of the l vs t graph gives the velocity of M. Maximum speed occurs when displacement x = 0.

(ii)



(d) (i) T: Tension
U: Upthrust
W: Weight of M.



FBD of M

T + U = W

T = W – U = 1.40 - $V_{submerged}\rho_{liquid}g$ = 1.40 – (20 x 10^{-6} x 1000 x 9.81)

T = 1.204 N

From graph, length = 0.277 m.

Alternatively,
Using F = kx, determine the extension x when the force is 1.204 and find the final length.

(ii) 1. The amplitude of the oscillation would reduce over time due to the damping by the liquid which dissipates the energy from the system.

2. The period of oscillation would be larger due to the resistive force produced by the liquid opposing the restoring force of the spring.

2

(a) (i) $P = \frac{V^2}{R} = \frac{(12)^2}{2.4} = 60$ W

(ii) Q = $mc\Delta\theta$

Pt = $mc\Delta\theta$

$$mc\Delta\theta = \frac{Pt}{m\Delta\theta} = \frac{(60\times 210)}{0.140\times(45-25)} = 4500 \text{ Jkg}^{-1}\text{K}^{-1}$$

(b) As the top of the liquid is not insulated, there is heat loss to the surrounding, thus less energy is actually required to heat up the liquid than what was determined in the experiment.

3

(a) (i) The I-V graph is not linear thus the diode is non-ohmic implying that the resistance is not constant.

From V = 0 V to V = 0.12 V, there is no current flowing, the resistance of the diode which is the ratio $\frac{V}{I}$ is infinite.

From V = 0.12 V to V = 1.08 V, the current is increasing while the resistance of the diode is always reducing.

(ii) From graph,

I = 4.4 mA

$$R = \frac{V}{I} = \frac{0.8}{4.4\times 10^{-3}} = 182\ \Omega$$

(b) When the PD across the diode is 0.8 V, the resistance of the diode is 182 Ω from (a)(ii).

By PDP,

$$V_{diode} = \frac{182}{(182 + R_{\text{variable resistor}})} \times 1.5$$

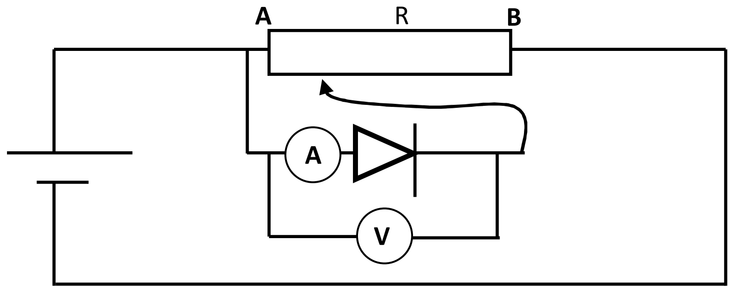
$$R_{\text{variable resistor}} = 159.3\ \Omega$$

the resistance of the variable resistor must be 159.3 Ω which is above the value of the maximum resistance of 100 Ω, therefore it is impossible to even attain a PD of 0.8 V.

Alternatively,

It is impossible for the potential difference across the diode to be zero volts. This is because even if the resistance of R is a maximum of a100 Ω, since the diode is in series with R and the value of resistance of the diode is quite substantial (as seen from a(ii)) by potential divider principle, it is not possible for the potential difference across the diode to be zero.

(c) (i)



(ii) When the slider is at position A of Resistance R, the PD across the diode is zero and when the slider moves to position B, the PD across the diode reaches a value of 1.5 V.

4

(a) The rate of change of momentum of the gas molecules during the collision between the gas molecules and the piston is the force exerted by the piston on the gas molecules. By Newton's Third Law, the gas molecules exert a force on the piston with equal magnitude and in opposite direction.

(b) As volume increases, the rate of collisions of the molecules against the walls decreases. However, as the temperature is increased, the kinetic energy of the molecules is also increased, thereby increasing the force of each molecule on the wall. As a result, the overall force, and therefore pressure, exerted on the walls remains the same.

(c) $pV = nRT$, p is constant

$$\frac{V_2}{T_2} = \frac{V_1}{T_1}$$

$$V_2 = \frac{1.6\times10^{-3}}{(30+273.15)}(90+273.15) = 1.92\times10^{-3}\ \text{m}^3$$

(d) Work done by the gas = $1.1 \times 10^{-5} \times (1.92 - 1.6) \times 10^{-3} = 35.2$ J

(e) The difference between the heat absorbed by the system and the work done by the system equals to the increase in internal energy.

5

(a) Faraday's law states that the <u>magnitude of induced e.m.f. in a conductor is proportional to the rate of change of magnetic flux linkage through the conductor.</u>

(b) (i) $E_{max} = I_{max}R$

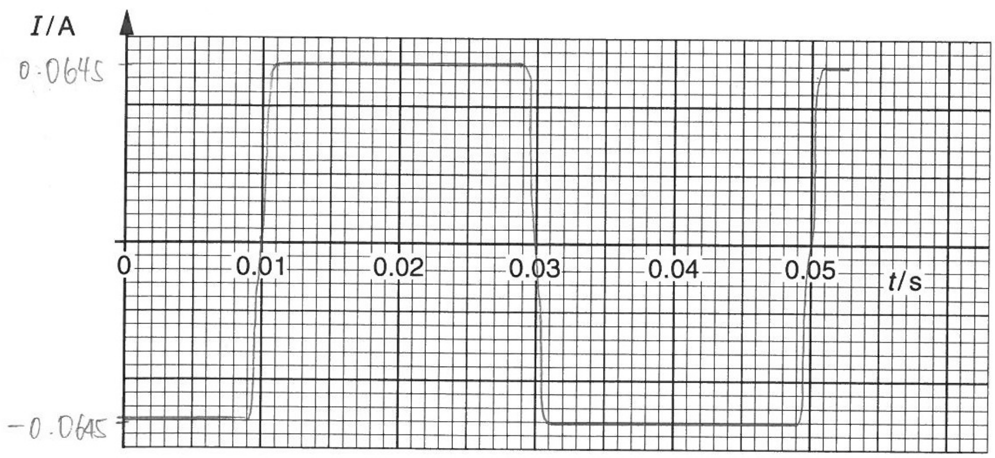
$$| E_{\max} | = NA \left| \frac{dB}{dt} \right|_{\max}$$

$$\left| \frac{dB}{dt} \right|_{\max} = \frac{(2.4-0)\times 10^{-2}}{0.009-0} = 2.67 \text{ T s}^{-1}$$

$$| E_{\max} | = NA \left| \frac{dB}{dt} \right|_{\max} = 500 \times 7.25 \times 10^{-4} \times 2.67 = 0.968 \text{ V}$$

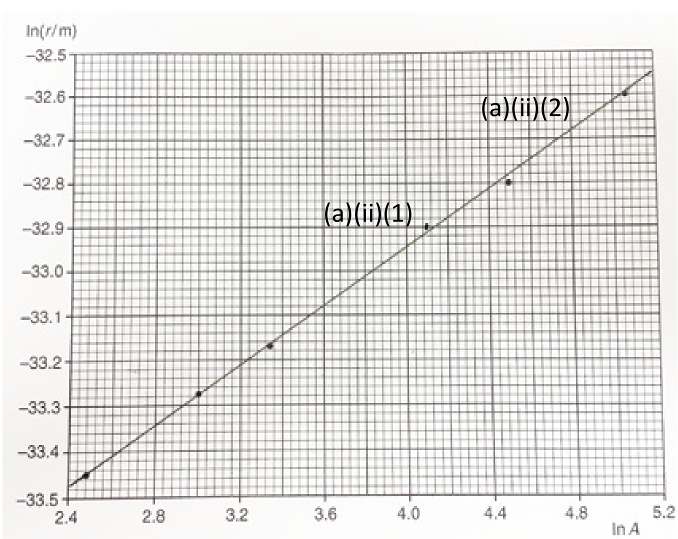
I_{max} = 0.968 / (10.0+5.00) = 0.0645 A

(ii)



6 (a)(i) When A = 60, from the graph, r = 5.1 x 10^{-15} m
Therefore ln r = -32.9

(a)(ii) When A = 60, ln A = 4.1



(a)(iii) Gradient = [-32.60 – (33.34)]/(5.14 – 2.8)
= 0.74/2.34 = 0.316

(a)(iv) Given $r = kA^n$, (linearise the equation)

$\ln r = n \ln A + \ln k$

Using (5.14, -32.60) from the best fit line,we have

$-32.60 = 0.316 (5.14) + \ln k$

Thus $\ln k = -34.2$

$k = 1.40 \times 10^{-15}$ m

(a)(v) k is the radius of the hydrogen atom, i.e. the proton.

(b)(i) $R_{uranium} = 1.40 \times 10^{-15} (235)^{0.316}$

$= 7.86 \times 10^{-15}$ m

(b)(ii) $\dfrac{\text{density of a hydrogen-1 nucleus}}{\text{density of a uranium-235 nucleus}} = m_H/V_H \div m_U/V_U$

$= m_H/m_U \times V_U/V_H$

$= 1/235 \times (r_U/r_H)^3$

$= 1/235 \times (7.86/1.40)^3$

$= 0.753$

(c)(1) In gaseous form, the intermolecular distance of the hydrogen gas is much further than the interatomic distance of the uranium metal, thus affecting the calculation of volume.

(c)(2) In gaseous form, hydrogen is a diatomic gas, thus affecting the calculation of mass.

Alternative solution, the density of the gas is not really a constant because the gas can be compressed, therefore the ratio will be different (depending on the other conditions like pressure and temperature.)