Tan Shi Yong V3S6H Physics Add Ex- Ideal Gas

Subject: Date: 31/1/04

1) C

$P_I V_I = P_F V_F$

$\cancel{V_F = \frac{P_i V_i}{P_f}}$ $h \cancel{\rho g} V_I = \frac{h}{2} \cancel{\rho g} V_F$

~~When h is halved, P is halved,~~ $\cancel{V_F = 2V_i}$ $V_F = 2V_I$

2) B

$\cancel{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$ Let x be no. of molecules

$\cancel{\frac{(80)N}{400} = \frac{(40)N}{800}}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{P_1(\frac{x}{N_1})}{T_1} = \frac{P_2(\frac{x}{N_2})}{T_2}$

$\frac{80(\frac{1}{N_1})}{400}$ $\cancel{N_2} = \frac{40(\frac{1}{N_2})}{800}$

$N_2 = \frac{2}{3} N_1$

3) C

$E_k = \frac{3}{2} nRT$

E_k of 1 molecule $= \frac{3}{2} kT$

$\therefore E_k$ is unaffected by molar mass; only C_{rms} is affected

4a) Elastic collision.

4bi) Time taken to travel $l = \frac{2l}{u}$

f ~~Rate of collisions~~ $= \frac{u}{2l}$

4bii) $F = ma$

$= \frac{mu^2}{l}$

$= muf$

4biii) $p = \frac{F}{A}$

$= \frac{muf}{V}$

4c) Root mean square speed.

4d) $p = \frac{1}{3} \rho C_{rms}^2$

$p = \frac{1}{3} \frac{Nm}{V} C_{rms}^2$ —— (1)

$p = \frac{n}{V} RT$ —— (2)

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Subt (1) into (2): $\frac{1}{3}Nmc_{rms}^2 = nRT$ ——— (3)

$E_k = \frac{1}{2}Nmc_{rms}^2$ ——— (4)

Subt (3) into (4): $3nRT = Nmc_{rms}^2 = 2E_k$

$E_k = \frac{3}{2}nRT$

$= \frac{3}{2}NkT$

5a) $\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$p \propto T$

Since P–T graph is a straight line, the gas behaves as an ideal gas.

5bi) $pV = nRT$

$n = \frac{pV}{RT}$

$= \frac{(207.5\times1000)(1.0\times10^{-3})}{(8.314)(500)}$

$= 0.0499$ (3s.f)

5bii) Mass $= 0.0040 \times 0.04992$

$= 2.00 \times 10^{-4}$ kg. (3s.f)

5ci) Work done $= 0$ J since V is constant

5cii) $\Delta u = q$

$= \frac{3}{2}nR(T_f - T_i)$

$= \frac{3}{2}(0.04992)(8.314)(500-300)$

$= 125$ J (3s.f)

5ciii) $q = \Delta u$

$= 125$ J (3s.f)

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5d) Total mass $= 2.00 \times 10^{-4}$ kg (3 s.f)

5e) $V = 1.0 \times 10^{-3}\ m^3$

$m_H = 1.00 \times 10^{-4}$

$m_{He} = 1.00 \times 10^{-4}$

$n_H = \frac{1.00 \times 10^{-4}}{0.0020}$

$= 0.005$

$n_{He} = \frac{1.00 \times 10^{-4}}{0.0040}$

$= 0.0025$

Total $n = 0.005 + 0.0025$

$= 0.0075$

$p = \frac{nRT}{V}$

$= \frac{(0.0075)(8.314)(300)}{1.0 \times 10^{-3}}$

$= 18700$ Pa (3 s.f)

5f) It will not be a straight line as the gas is not ideal.

Thermodynamics

1) C $P = \frac{mc\Delta\theta}{t} + Loss$

$Loss = 2500 - \frac{1 \times 4000 \times 80}{200}$

$= 0.90$ kW

2) ~~B~~ C Some energy is needed to form van der waals' attractions during change in phrase from liquid to solid when melting point is reached.

3) B Elimination A) $\Delta U \neq 0$ all the time when heat enters or leaves as there may be ΔW

~~B) When ΔQ is +ve & T is constant, ΔW is positive & hence ΔU is positive~~

~~D) Not true~~ C) Not true

D) May also be work done against ga

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4a)

~~P is constant, m & c are constants,~~

$P = \frac{mc\Delta\theta}{t}$

$Pt = mc\Delta\theta$

$t \propto \Delta\theta$

$t = k\Delta\theta$

$160 = 10k$

$k = 16$

$k = \frac{mc}{P}$

$\frac{mc}{P} = 16$

$mc = 16P$

$c = \frac{16P}{m}$

Units of $\frac{P}{m} = J s^{-1} kg^{-1}$

$P = \frac{mc\Delta\theta}{t}$

$\frac{\Delta\theta}{t} = \frac{10}{160}$

$= 0.0625\ K s^{-1}$

$P = 1600 \times 0.0625 \times m$

$= 100m\ J s^{-1}$

$Q_{fusion} = 100m \times (400-160)$

$= 24000m\ J$

$Q = ml$

$l = \frac{Q}{m}$

$= 24000\ J kg^{-1}$

4b)

$P = \frac{mc\Delta\theta}{t}$

$c = \frac{P \cdot t}{m\Delta\theta}$

$= \frac{100m \times (600-400)}{m \times (73-63)}$

$= 2000\ J kg^{-1} K^{-1}$

5ai) An adiabatic change is one that takes place such that no heat flows into or out of the system.

$\Delta U = W\ ; \Delta q = 0$

5aii) For the system of an ideal monatomic gas, the internal energy is solely energy of translation, as an ideal gas has no ~~intermolecular~~ interatomic forces of ~~attr~~ attraction. $U = E_k = \frac{3}{2}nRT$

The internal energy of a real gas comprises kinetic energy of ~~translation~~ rotation and vibration as well as translation. There are also intermolecular forces of attraction.

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5a(ii) In the evaporation process, the molecules need to overcome the intermolecular attractions to separate and become independent molecules, while at the same time doing work in expanding against the atmosphere.

In the melting process, the molecules need only to break down and escape from the crystalline structure to have the higher degree of freedom and disorder that characterizes a liquid state.

Hence the latent heat needed in evaporation is expected to be higher than for fusion since no heat energy is expended as work done in the case of melting.

5b(i)

$$\cancel{\Delta Q}\ \Delta U = \Delta Q + \Delta W$$

The ~~change in~~ increase in the internal energy of a system is the sum of the heat supplied to the system (gas) and the work done on the system (gas).

5b(ii)

$$P_i V_i = P_f V_f$$

$$P_f = \frac{P_i V_i}{V_f}$$

$$= \frac{200000(10 \times 10^{-3})}{(\frac{1}{2} \times 10 \times 10^{-3})}$$

$$= 400\ kPa$$

$$\frac{P_i}{T_i} = \frac{P_f}{T_f}$$

$$P_f = \frac{P_i}{T_i} \times T_f$$

$$= \frac{400000}{(273+27)} \times 450$$

$$= 600\ kPa$$

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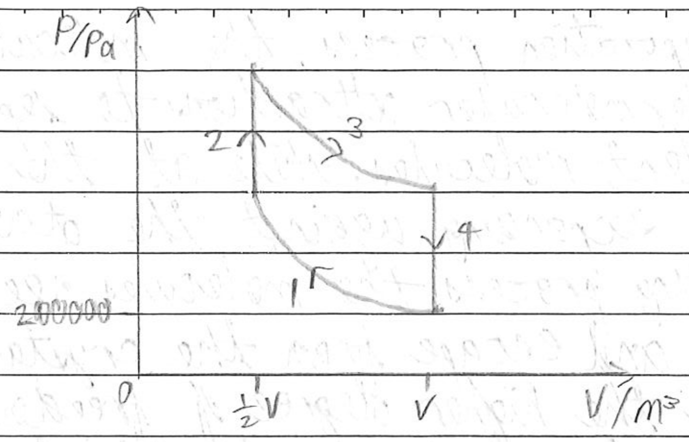

5b(ii) Work done = $-nRT \ln \frac{V_f}{V_i}$

Subject: Waves

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1) D. A. Sound waves are always longitudinal

B. ~~No. E.g.~~ Not always. E.g. electromagnetic waves

C. Speed is $3 \times 10^8\ ms^{-1}$ only in vacuum

2) B

$I \propto \frac{1}{x^2}$

$I \propto A^2$

$A^2 \propto \frac{1}{x^2}$

$A^2 = k \times \frac{1}{x^2}$

$A = \frac{1}{x}\sqrt{k}$; grad constant

$\therefore$ graph of A against $\frac{1}{x}$ is a straight line

3) B

$f = \frac{1}{T}$

$= \frac{1}{0.8}$

$= 1.25\ Hz$

$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$

$\Delta \phi = \frac{\Delta x}{\lambda} \times 2\pi$

$= \frac{0.2}{0.8} \times 2\pi$

$= \frac{\pi}{2}$

4) Power dissipated as light $= \frac{10}{100} \times 100$

$= 10\ W$

Surface area of sphere $= 4\pi r^2$

$= 4\pi (20000)^2$

$= 5.0 \times 10^{13}\ cm^2$

Power entering eye $= 0.5 \times \frac{10}{5.0 \times 10^{13}}$

$= 1.0 \times 10^{-13}\ W$

5a) ~~Soo~~ Sound waves travel via ~~air molecules~~ particles striking each other. The particles move in the direction of energy transmission creating a series of compressions and rarefactions, hence sound waves are longitudinal.

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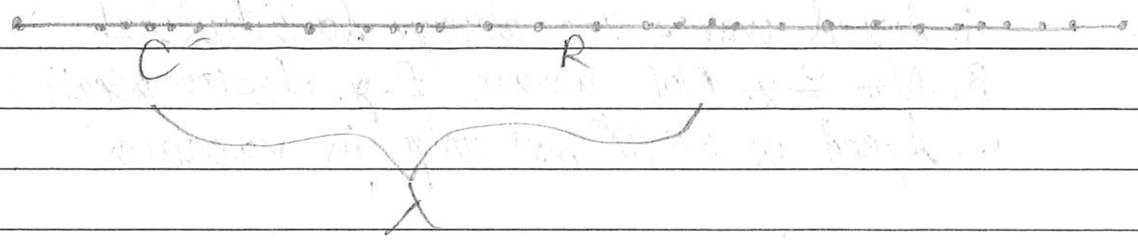
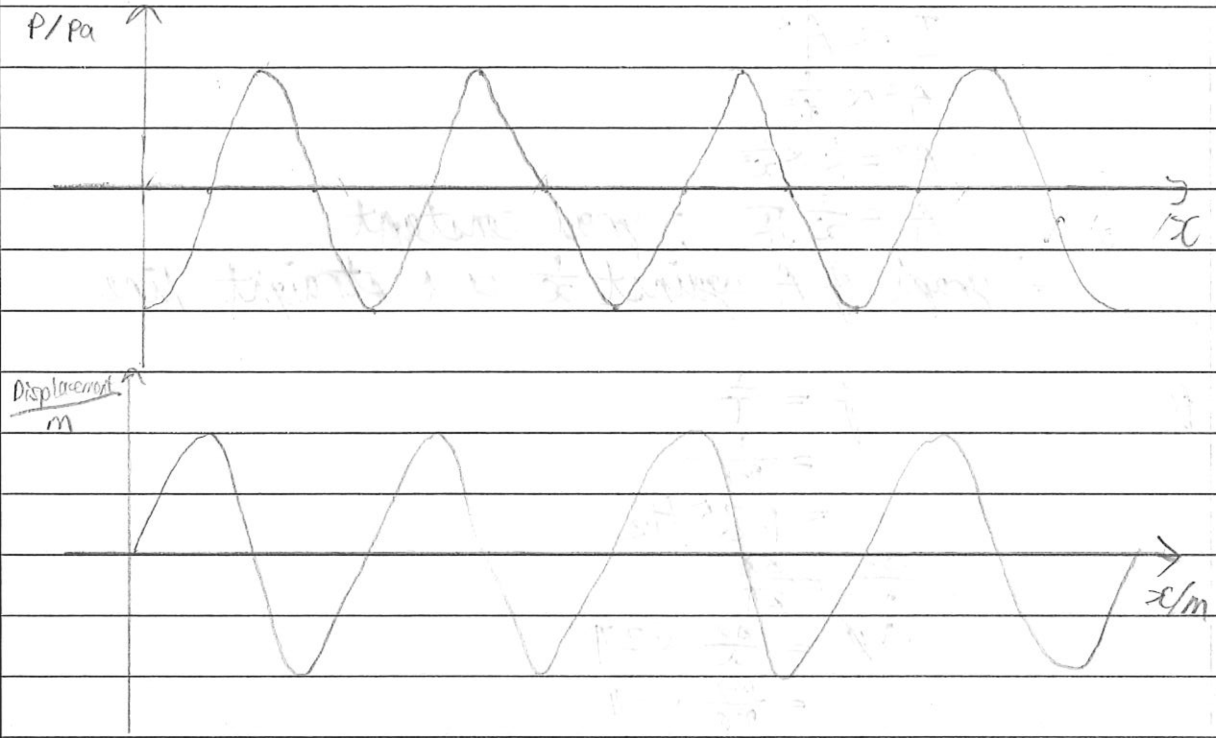
5b)



5c)



5d)

$V = \frac{\lambda}{T}$

The wave speed is constant but the speed of the atoms is ~~xx~~ not constant.

Subject: Oscillations

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1) B

$$Max\ V = x_0 \omega$$
$$= 1.0 \times \frac{2\pi}{T}$$
$$= 1.0 \times \frac{2\pi}{\cancel{8.0}\ 4.0}$$
$$= 1.6\ ms^{-1}\ (2\ s.f)$$

2) C. When $t=0$, $x=x_0$, $v = x_0 \omega \sin(\omega t)$

$$a = \cancel{-\omega^2 x}\ -\omega^2 x_0 \cos(\omega t)$$

∴ v-t graph is a sine graph
a-t graph is a cosine graph

3)
$$E_k = \frac{1}{2} m \omega^2 (x_0^2 - x^2) \qquad \omega = 2\pi f$$
$$\omega^2 = \frac{2E_k}{m(x_0^2 - x^2)}$$
$$\omega = \sqrt{\frac{2E_k}{m(x_0^2 - x^2)}}$$

$$V_{max} = x_0 \omega$$

4ai) The natural frequency of oscillation is the frequency at which resonance occurs.

4aii)
$$T = 2\pi \sqrt{\frac{m}{k}}$$
$$\frac{m}{k} = \left(\frac{T}{2\pi}\right)^2$$
$$k = \frac{m}{\left(\frac{T}{2\pi}\right)^2}$$
$$= \frac{40}{\left(\frac{1.6}{2\pi}\right)^2}$$
$$= 617\ (3\ s.f)$$

4bi) ~~Res~~ Resonance occurs.

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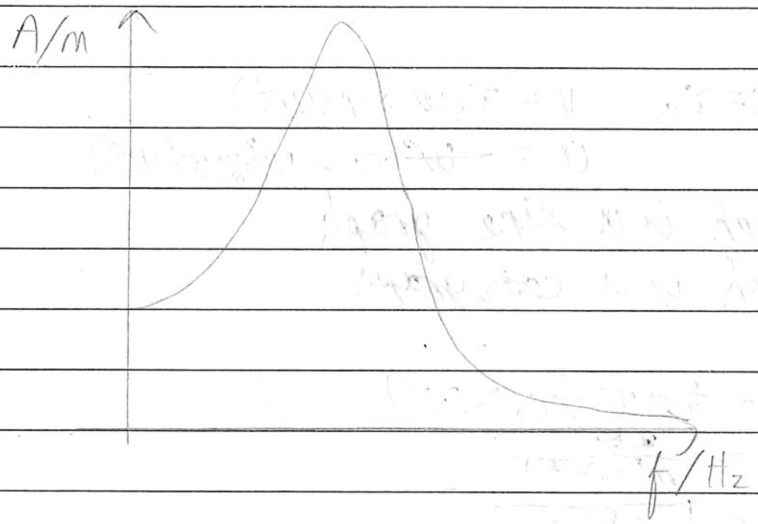
4bii) $\omega = \frac{2\pi}{T}$

$= \frac{2\pi}{1.6}$

$= 1.25\pi \text{ rev } s^{-1}$

4biii) 

4biv) The period will be lower.

5a) The amplitude of the oscillation decreases exponentially with time.

5bi) $2.5T — 2.0 \times 10^{-3} s$

$T — \frac{2.0 \times 10^{-3}}{2.5}$

$= 8.0 \times 10^{-4} s$

$f = \frac{1}{T}$

$= \frac{1}{8.0 \times 10^{-4}}$

$= 1250 Hz$

5bii) $\max a = -\omega^2 x_{max}$

$= -(2\pi(1250))^2(\frac{6}{1000})$

$= -3.7 \times 10^5 ms^{-2}$

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15d) ~~f~~ $\lambda = 3.5\ \mu m$

$= 3.5 \times 10^{-6}\ m$

$v = f\lambda$

$f = \frac{v}{\lambda}$ —— (1)

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ —— (2)

subt (1) into (2): $\frac{v}{\lambda} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$\frac{3 \times 10^{8}}{3.5 \times 10^{-6}} = \frac{1}{2\pi}\sqrt{\frac{k}{1.7 \times 10^{-27}}}$

$k = \left[\left(\frac{3 \times 10^{8}}{3.5 \times 10^{-6}}\right)(2\pi)\right]^2 (1.7 \times 10^{-27})$

$= 493\ Nm^{-1}$ (3s.f)

Capacitance, Charge & Field

1) A $Q = CV$

~~Q on $C_1 = 3.0 \times 10^{-6} \times 3$~~

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2 + C_3}$

Total Q ~~is split evenly between~~ of C_1 & $C_2 + C_3$ is same

$Q_{C_1} = \cancel{C_2} \; Q_{C_2} + Q_{C_3}$

$Q_{C_1} = 2Q_{C_2}$

$\frac{1}{C_{eq}} = \frac{1}{3.0 \times 10^{-6}} + \frac{1}{6.0 \times 10^{-6}}$

$C_{eq} = 2.0 \times 10^{-6}\ F$

$Q_T = 2.0 \times 10^{-6} \times 3.0$

$= 6.0 \times 10^{-6}\ C$

$\therefore Q_{C_1} = 6.0 \times 10^{-6} C$

$\therefore Q_{C_2} = Q_{C_3}$

$= 3.0 \times 10^{-6} C$

2) D In series, each capacitor stores the same amount of charge. Only if ~~circu~~ capacitors are in parallel does $6\mu F$ store 2x charge of $3\mu F$.

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3) C. The dielectric does not have constant potential

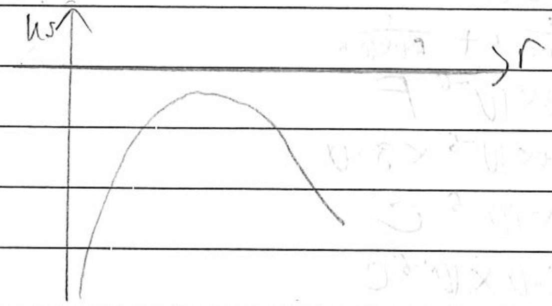
4) C At a point closer to Q, net field is 0 as strength of fields excerted by P & Q are of same magnitude in opposite directions, cancelling out each other.

5) A Direction of conventional current is opposite to direction of electric and magnetic fields, hence the electrons slow down.

6a) It means -1.77×10^{9} J of work is done to bring a 1kg mass from infinity to that point.

6bi)
$$U_s = \frac{GM_sM_B}{x-r} - \frac{GM_sM_A}{r}$$
$$= GM_s\left(\frac{M_B}{x-r} - \frac{M_A}{r}\right)$$

6bii)



6biii) As the shuttle moves farther away from planet A, F_s on it decreases as r increases, therefore U_s increases.
$$F_s = \frac{GM_sM_A}{r^2}$$
However, F_s will increase due to gravitational potential of planet B, which it is approaching, hence U_s will decrease.

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7d) At highest position, $v = 0\ ms^{-1}$

$$K.E\ lost = \frac{1}{2}m(\Delta v)^2$$
$$= \frac{1}{2}(9.110\times10^{-31})(4.19\times10^{6})^2$$
$$= 8.00\times10^{-18}\ J$$

8ai)

$$F = BIL\sin\theta$$
$$= 50\times10^{-6}\times3.2\times10^{-19}\times3.0\times10^{7}\times\sin 90^\circ$$
$$= 4.8\times10^{-16}\ N$$

8aii)

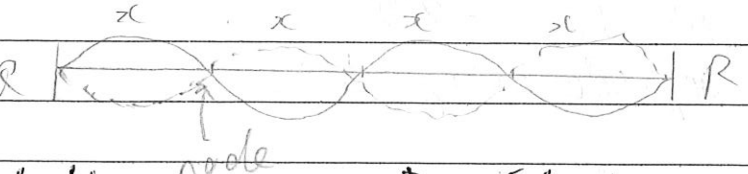
$$r = \frac{mv}{Bq}$$
$$= \frac{(6.7\times10^{-27})(3.0\times10^{7})}{(50\times10^{-6})(3.2\times10^{-19})}$$
$$= 12.6\ km\ (3\ s.f)$$

8b) It will travel in a circular path as it is moving at right angles to a magnetic field and hence experiences a force at right-angles to its direction of motion.

Superposition

1) A. $\lambda = 2x$

∴ nodes of wave ~~at~~ are at the points where paper is resting, that is ~~every x part~~ x apart



2) C. In double-slit ~~λ = ...~~ interference, the first maximum away ~~$\lambda = \frac{ax}{L}$~~ from the centre occurs when path difference ~~= ...~~ equals wavelength. ~~Since light waves~~ Since light from S_2 is delayed, waves from S_2 $\frac{\pi}{2}$ out of phrase of S_1's take longer to hit the screen and maxima is shifted towards Y by $\frac{1}{4}\lambda$.

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3) D $\cancel{d \sin\theta = n\lambda}$ $\theta = \frac{\lambda}{d}$

When d is reduced by $\frac{1}{2}$, θ is increased by ~~2~~ 2x, hence diffraction pattern ~~grating~~ is doubled in spacing.

4a) They are π rad out of phrase.

4b) Since waves are ~~$\frac{\pi}{2}$ out~~ ~~θ rad~~ π rad out of phrase, destructive interference occurs when they converge at an equal distance from their transmitters.

4c) The ship has moved ~~$\frac{\pi}{4}\lambda$.~~ $\frac{1}{4}\lambda$.

Distance $= \frac{1}{4} \times 300$

$= 75m$

$\Delta\phi_s = \pi$

$\Delta\phi_p = \frac{\pi}{4}$

$\Delta\phi = \pi + \frac{\pi}{4}$

$= \frac{5}{4}\pi$

Waves will be in phrase and constructive interference occurs.

4d) No. of $\frac{1}{2}\lambda = \frac{30000}{150}$

$= 200$

There is an antinode and a node every $\frac{1}{2}\lambda$.

5di) $d \sin\theta = n\lambda$

$\cancel{4}\,1.5 \times 10^{6} \sin 162.7° = 4\lambda$

$4\lambda = 6.61 \times 10^{-7} m$

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5aii) ~~Since θ is larger,~~ Since θ of second order spectrum is larger, it will give a more ~~ca~~ accurate value of wavelength.
The disadvantage is that the second and third order spectrums are both green and this may cause errors in measurement.

5 b)
$\cancel{d \sin\theta = n\lambda}$ $\cancel{\theta = \frac{\lambda}{d}}$

$\cancel{\theta = \frac{60^\circ}{2}}$ ~~When d is doubled,~~

$\cancel{= 30^\circ}$ $\sin\theta = \frac{n\lambda}{d}$

$\cancel{d \sin 30^\circ = \lambda}$ $\propto \frac{1}{d}$

$\cancel{\sin 30^\circ = \frac{\lambda}{d}}$ $\sin\left(\frac{60}{2}\right) = \frac{k}{d}$ —— (1)

when ~~d~~ d doubles, $\sin\theta = \frac{k}{2d}$ —— (2)

(2) ÷ (1): $\frac{\sin\theta}{\sin 30} = \frac{1}{2}$

$\theta = 29.0^\circ$ (3s.f)

Quantum Physics

1) B $E = hf$

The greater the difference in energy level during transition, the higher the f. Therefore there are 2 lines of high f & 1 line of low f.

2) D $\cancel{\phi} = 3.2 \times 10^{-19}$ eV $\frac{1}{2}mv^2 = hf - \cancel{\phi}$

$\lambda = 355 \times 10^{-9}$ m. When K.E = 0 J, $hf = \cancel{\phi}$

$\frac{hc}{\lambda} = 3.2 \times 10^{-19}$

3) C $E_3 = E_1 + E_2$

$\cancel{\frac{hc}{f_3} = \frac{hc}{f_1} + \frac{hc}{f_2}}$ $hf_3 = hf_1 + hf_2$

$\cancel{\frac{1}{f_3} = \frac{1}{f_1} + \frac{1}{f_2}}$ $f_3 = f_1 + f_2$

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3) ~~C.~~ $\cancel{E_3 = E_1 + E_2}$

$\cancel{hf_3 = hf_1 + hf_2}$

$\cancel{f_3 = f_1 + f_2}$

4a) ~~photoelect~~ photoelectric effect.

4b) ~~10^2 2^{10}~~ No. of electrons $= 2^{10}$

$= 1024$

4c) $e = 1.6 \times 10^{-19} J$

$P = nhf$

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6c i)

$$F = ma$$
$$= m\frac{v^2}{r}$$
$$\frac{GMm}{r^2} = m\frac{v^2}{r}$$
$$mv^2 = \frac{GMm}{r}$$
$$E_k = \frac{1}{2}mv^2$$
$$= \frac{GMm}{2r}$$

~~Since K.E and~~ U has a negative sign to show that the astroid is bounded to the Earth by the latter's gravitational attraction and is never able to escape i.e. the orbit is stable

E_k has a positive sign

$\therefore$ E_k ~~has~~ is equal to $-\frac{1}{2}$ times the U

6c ii)

$$E_T = E_k + U$$
$$= \frac{GMm}{2r} - \frac{GMm}{r}$$
$$= -\frac{GMm}{2r}$$

6c iii) 1.

r at A = a

$$\frac{GMm}{2a} = \frac{1}{2}mv^2$$
$$v^2 = \frac{GM}{a}$$
$$v = \sqrt{\frac{GM}{a}} \text{ ms}^{-1}$$

2. r at C = 2a

$$\frac{GMm}{4a} = \frac{1}{2}mv^2$$
$$v = \sqrt{\frac{GM}{2a}} \text{ ms}^{-1}$$

7a)

~~$C = \frac{\varepsilon A}{d}$~~
~~$= 5.0 \times 10^3 \times$~~

$$E = \frac{V}{d}$$
$$V = Ed$$
$$= \frac{1}{100} \times 5 \times 10^3$$
$$= 50\text{ V}$$

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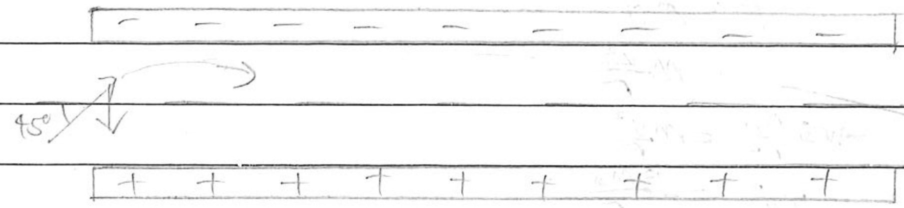
7b)



Force $= qE$

$= 1.6\times10^{-19} \times 5\times10^{3}$

$= 8.0\times10^{-16}\,N$

$F = ma$

$a = \frac{F}{m}$

$= \frac{8.0\times10^{-16}}{9.110\times10^{-31}}$

$= 8.78\times10^{14}\,ms^{-2}$

7c)

$\cancel{u = v + at}$ $\cancel{s = ut + \frac{1}{2}at^2}$ $v^2 = u_{ver}^2 + 2as$

a is in opposite direction to vertical component of velocity $\therefore$ a is negative

Max $s = \frac{1.0}{2\times100}$

$= 5.0\times10^{-3}\,m$

$a = -8.78\times10^{14}\,ms^{-2}$

$\cancel{u = 0\,ms^{-1}}$ $V = 0\,ms^{-1}$

$\cancel{V = \sqrt{2as}}$ $u_{ver}^2 = -2as$

$\cancel{= \sqrt{2(-8.78}}$ $u_{ver} = \sqrt{-2as}$

$= \sqrt{-2(-8.78\times10^{14})(5.0\times10^{-3})}$

$= 2.963\times10^{6}\,ms^{-1}$

Max speed $= \cancel{2\times(2.96\times10^{6})^2}$ $\sqrt{2(2.96\times10^{6})^2}$

$= 4.19\times10^{6}\,ms^{-1}$