Paper 2

1 a) $F_{spacecraft} = F_{ions}$ (N3)

$$\overset{ma}{\rightsquigarrow} 740\,a = \frac{6.6\times10^{-6}\times5.2\times10^{4}}{1} \leftarrow \frac{\Delta p}{t}$$

$$a = 4.6\times10^{-4}\ \mathrm{ms^{-2}}$$

b) i. 30 kg remaining for acceleration

$$\text{time for acceleration} = \frac{30}{\underset{\leftarrow\ \text{mass per second}}{6.6\times10^{-6}}} = 4.6\times10^{6}$$

$$\text{speed} = \overset{\text{from (a)}}{a}t = 4.6\times10^{-4}\times4.6\times10^{6}$$

$$= 2.1\times10^{3}\ \mathrm{ms^{-1}}$$

ii.
- Too complicated if exact
- Simplify equations / calculations
- Some quantities unknown / imprecise

c) i. Same charge so repel
(✓) (✓)

ii. Forces between ions are perpendicular to spacecraft motion so do not affect force on spacecraft → no effect on acceleration.

d) i. force per unit mass acting on a small test mass at that point in the field

ii. Satellite size << planet so approximately point mass.

2.a) Minimum radius → maximum resistance

$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$ $\quad r = \sqrt{\frac{\rho l}{\pi R}} = \sqrt{\frac{7.2 \times 10^{-7} \times 12.5}{\pi \times 0.1}}$

$= 5.352 \times 10^{-3}$

$= 5.4 \times 10^{-3}$ m (2sf)

b) Current, $I = \frac{P}{V} = \frac{5}{24} = 0.21$ A in lamp

Max current from power supply is 8 A

$n_{lamps} = \frac{8}{0.21} = 38.4\ldots$ round <u>down</u> to 38 lamps

c)
- brightness remains the same as more lamps added
- potential difference across each remains the same
- current through ″
- independent control

3.a) $\underset{\text{resultant}}{F} = \frac{m\overset{0}{\cancel{v}} - mu}{t} \leftarrow \frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh} = \sqrt{2\times 9.81\times 1.1}$

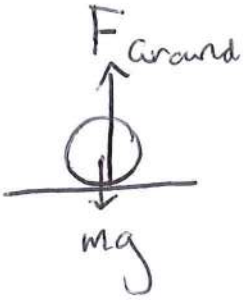
$mu = 0.058\times\sqrt{2\times 9.81\times 1.1}$

$= 0.27\ \text{kg ms}^{-1}$

Resultant force $= F_{Ground} - mg = \frac{0.27}{0.055}$

$F_{Ground} = 4.9 + mg$

$= 5.5\ \text{N}$



b) Concrete reduces time over which egg brought to rest.

For the same change in momentum, this increases force. (Deceleration larger)

4. a) [Notice the labels on the axes]

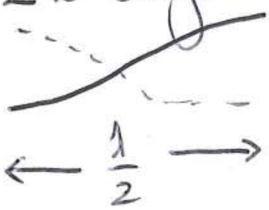
The air molecule moves to the right (to a maximum displacement) then back ~~for~~ through X to the left. It returns to its original position.

b) $K = c^2\rho$

NB: $c = f\lambda$

λ is 2× length of pipe

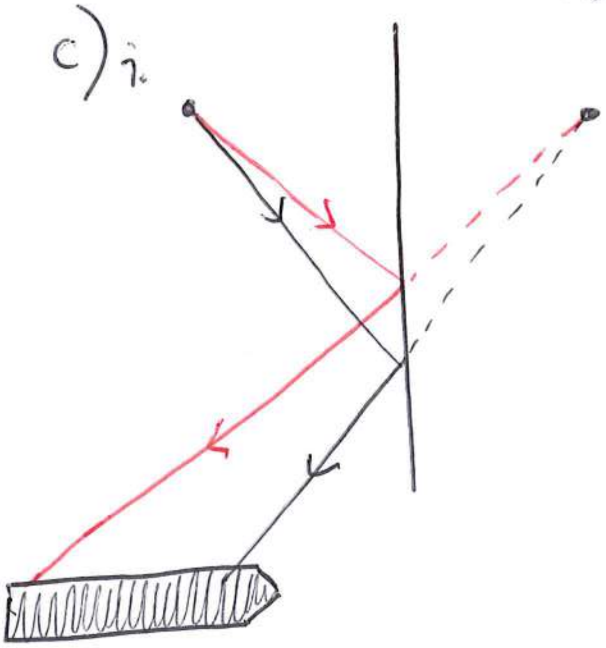
$= f^2\lambda^2\rho$



$= 120^2 \times 2.8^2 \times 1.3$

$= 1.5 \times 10^5 \ \mathrm{kg\,m^{-1}\,s^{-2}}$ ← quick check!

c) i.



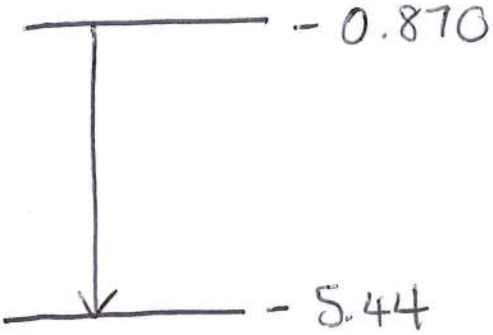
ii. Interference pattern:

- maximum when waves occur in phase
- minimum when waves occur 180° out of phase

5. (a) $E = hf = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times 3\times10^{8}}{435\times10^{-9}}$

$= 4.6\times10^{-19}$ J

b) "emmited" [and check units in case eV]



[or ecf]

c) Difference in energy levels equal to energy of photon

Downward arrow as energy is lost by the hydrogen and given to ~~photot~~ photon.

6a) $I \propto \frac{1}{r^2}$

$$I_{Mars} = I_{Earth} \times \left(\frac{r_{Earth}}{r_{Mars}}\right)^2 = 1.36\times10^3 \times \frac{1}{1.5^2}$$

$$= 604\ Wm^{-2}$$

$I \times \pi r^2$

b) $I = \frac{P}{A} = \sigma T^4$

$\div 4\pi r^2$

$$\frac{I}{4} = \sigma T^4$$

$$T = \sqrt[4]{\frac{600}{4\times5.67\times10^{-8}}} = 230\ K$$

c) Low pressure → low concentration of CO_2
Too few molecules to produce heating effect due to re-radiation

7. a) Internal energy is defined as the sum of the kinetic energies ~~of~~ and potential energies of all of the molecules. (✓)

At "boiling point", temperature same for both so same KE (✓)
(✓)
But gas has no potential energy [which is higher than the negative energy in liquid bonds]
Gases have higher internal energy (✓)

b) i. $0.25 \text{ mol s}^{-1} = 0.25 \times 32 \text{ gs}^{-1} = 8 \text{ gs}^{-1}$

$\text{Heat s}^{-1} = P = 8 \times 10^{-3} \times 2.1 \times 10^{5} = 1700 \text{ Js}^{-1}$
$= 1.7 \text{ kW}$

ii. $pV = nRT$

$$V = \frac{nRT}{p} = \frac{0.25 \times 8.31 \times 260}{0.11 \times 10^{6}} = 4.9 \times 10^{-3} \text{ m}^{3}$$

c) • ideal gas assumes monatomic (oxygen is diatomic)
• elastic collisions
• "molecules" are point objects
• no intermolecular forces
• will not liquefy