Worked Solutions - 31/3 Revision Session

1)a) i) The minimum energy required to remove an electron from the surface of metal

ii) Photons have energy dependent on their frequency
- There is a 1-to-1 interaction between photon and electron.
- Maximum k.E of electron following this is $E_{k\,max} = E_{photon} - \phi$
- However, for deeper electrons, require more than ϕ energy to remove.

iii) $E_{k\,max} = 3.51 \times 10^{-20}$ J

$\phi = 4.07$

$E_{photon} = hf = E_{k\,max} + \phi$

$$f = \frac{E_{k\,max} + \phi}{h}$$

$$= \frac{3.51\times10^{-20} + 4.07\times1.60\times10^{-19}}{6.63\times10^{-34}}$$

$$= 1.04 \times 10^{-15} \text{ Hz}$$

b) - Theory makes prediction.
- These are tested by experiments that can be repeated and peer reviewed.

2)a) Electron diffraction

b) $$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.5\times10^{5}}$$

$$= 2.9\times10^{-9} \text{ m}$$

c) $$v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}}{207\times9.11\times10^{-31}\times2.9\times10^{-9}}$$

$$= 1200 \text{ ms}^{-1}$$

3a) Hooke's Law: Extension is proportional to the force applied.
Only applicable up to limit of proportionality

b) i) $E = \frac{\sigma}{\epsilon}$, $\sigma = \frac{F}{A}$ $\epsilon = \frac{\Delta l}{l}$

$E = \frac{Fl}{A\Delta l}$

$\Delta l = \frac{Fl}{AE}$

For steel: $\Delta l = \frac{80 \times 0.80}{2.4\times10^{-6} \times 2.0\times10^{11}}$

$= 1.3\times10^{-4}$ m

For brass $\Delta l = \frac{80 \times 1.40}{2.4\times10^{-6} \times 1.0\times10^{11}}$

$= 4.7\times10^{-4}$ m

$\Delta l_{total} = 6.0\times10^{-4}$ m

ii) $\rho = \frac{m}{V} \Rightarrow m = \rho V$

$M_{steel} = 7.9\times10^{3} \times 2.4\times10^{-6} \times 0.80$
$= 1.5\times10^{-2}$ kg

$M_{brass} = 8.5\times10^{3} \times 2.4\times10^{-6} \times 1.40$
$= 2.9\times10^{-2}$ kg

$M_{total} = 4.4\times10^{-2}$ kg

c) $m = \rho V = \rho A l$

$l = \frac{m}{\rho A} = \frac{4.4\times10^{-2}}{8.5\times10^{3} \times 2.4\times10^{-6}}$

4)a)i) $\downarrow$ +ve

$s = 1.2m$
$u = 0$
$v =$
$a = 9.81 ms^{-2}$
$t = ?$

$s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 1.2}{9.81}}$

$= 0.49s$

ii) $\rightarrow$ +ve

$s = ?$
$u = 8.5 ms^{-1}$
v
$a = 0$
$t = 0.49s$

$s = ut$
$= 8.5 \times 0.49$
$= 4.2m$

b)i)

$s = 0.35m$
$u = 8.5 ms^{-1}$
$v = 0$
a
$t = ?$

$s = \frac{1}{2}(u+v)t$

$t = \frac{2s}{(u+v)}$

$= \frac{2 \times 0.35}{8.5}$

$= 0.082 s.$

ii) $a = \frac{v-u}{t} = \frac{8.5}{0.082}$

$= 104 ms^{-2}$

$F = ma$
$= 75 \times 104$
$= 7800N$

Horizontal component of friction needs to balance this so is also 7800N

5)a) Spectral analysis of light from stars
Measuring red shift of stars etc.

b)i) First order

ii) - Light at A will be white and B will be a spectrum.
- Greater intensity at A.

c) $\theta = 51°$ $N = 1480 \times 10^3$

$d = \frac{1}{N} = 6.76 \times 10^{-7} m$

$n\lambda = d \sin\theta$, $n = 1$.

$\lambda = 6.757 \times 10^{-7} \times \sin 51$
$= 5.25 \times 10^{-7} m$

d) If $n = 2$

$\theta = \arcsin\left(\frac{n\lambda}{d}\right)$
$= \arcsin\left(\frac{2 \times 5.25 \times 10^{-7}}{6.67 \times 10^{-7}}\right)$

$= \arcsin(1.55)$

which cannot be calculated.
No more beams.

6a)

Particle	Quark Structure	Charge	Strangeness	Baryon Number
proton p	uud	+1	0	1
Sigma+ Σ^+	uus	+1	−1	1
π^+ pi plus	ud	+1	0	0

b) i) proton
anti-proton (or similar)

ii) 3 anti-quarks.

iii) Same: Rest mass (energy)

Different: Baryon number / Strangeness etc.
Charge.