3IB Physics. Hand in Jan. 2009 TM – *Answers*

1. M05 TZ1 S1, H1: 1 - C
2. M05 TZ1 S1:3, H1: 2 – B
3. M05 TZ1 H1: 17 – B
4. M05 TZ1 S1:4 – A (speed?, not velocity?. Anyway wrong sign on u on graph)
5. M05 TZ1 H1: 8 – A
6. M05 TZ1 H1: 4 – B
7. M05 TZ1 S1:24 – D
8. M05 TZ1 S1:9 – A (Ra > Rc > Rs, Fs = ma + mg)
9. M05 TZ1 S1:16 – A (Q = Lm, if Q fixed, then greater L implies smaller evaporated m)
10. M05 TZ1 S1:10 – B
11. M05 TZ1 S1:28 – D
12. M05 TZ1 S1:23, H1: 29 – D
13. M05 TZ1 H1:34 – D
14. M05 TZ1 S1:26 – C (tilting a little down, pointing towards the Earth north pole which is a magnetic south pole)
15. M05 TZ1 S1:30, H1: 36 – A (Eb negative and decreasing, that is increasing in magnitude)

M05 TZ1 H2: A4
Answers will be open-ended but look for these main points.
Observation I:
energy is needed to eject the electrons from the surface;
according to the wave model, the energy of a wave depends on its amplitude / intensity;
so one would expect emission to depend on intensity not frequency;
Observation II:
according to the wave model, energy is delivered continuously to the surface;
so with a very low intensity wave;
one would expect the electrons to need a certain amount of time to gain sufficient energy to leave the surface.

M05 TZ1 S2:B2p1, H2: B1p1

(a) if the total external force acting upon a system is zero / for an isolated system;
the momentum of the system is constant;
*Award **[1 max]** if the answer is in terms of collisions.*

(b) 131 g of xenon contains 6.02×10^{23} / N_A atoms;

mass of 1 atom $=\dfrac{131}{6.02\times10^{23}}=2.2\times10^{-22}\,\text{g}=2.2\times10^{-25}\,\text{kg}$;

or

mass of nucleon 1.66×10^{-27} kg ;

mass of xenon atom $=131\times1.66\times10^{-27}\,\text{kg}=2.2\times10^{-25}\,\text{kg}$;

(c) time $=1.5\times3.2\times10^{7}=4.8\times10^{7}$ s ;

no of atoms per second $=\dfrac{81}{2.2\times10^{-25}\times4.8\times10^{7}}=7.7\times10^{18}\,\text{s}^{-1}$;

or

no of atoms in original mass $=\dfrac{81}{2.2\times10^{-25}}=3.7\times10^{26}$;

time $=\dfrac{3.7\times10^{26}}{7.7\times10^{18}}=4.8\times10^{7}\,\text{s}=1.5$ years ;

(d) rate of change of momentum of the xenon atoms
$=7.7\times10^{18}\times2.2\times10^{-25}\times3.0\times10^{4}$;
$=5.1\times10^{-2}\,\text{N}$;
= mass × acceleration ;
where mass $=(540+81)$ kg ;

to give acceleration of spaceship $=\dfrac{5.1\times10^{-2}}{6.2\times10^{2}}$;

$=(8.2\times10^{-5}\,\text{m s}^{-2})$

Accept if mass of fuel omitted $\left(=9.4\times10^{-5}\,\text{m s}^{-2}\right)$.

(e) $a=\dfrac{F}{m}$;

since m is <u>decreasing</u> with time, then a will be <u>increasing</u> with time;

(f) change in speed = area under graph;

$= (8.2 \times 4.8) \times 10^2 + \frac{1}{2}(4.8 \times 1.3) \times 10^2$;

final speed $= (8.2 \times 4.8) \times 10^2 + \frac{1}{2}(4.8 \times 1.3) \times 10^2 + 1.2 \times 10^3$;

$5.4 \times 10^3 \, \mathrm{m\,s^{-1}}$;

or

use of $v = u + at$

$u = 1.2 \times 10^3 \, \mathrm{m\,s^{-1}}$;

average acceleration from the graph $= \frac{1}{2}(8.2 + 9.45) \times 10^{-5}$;

$= 8.8 \times 10^{-5} \, \mathrm{m\,s^{-2}}$;

final speed $= 4.8 \times 10^7 \times 8.8 \times 10^{-5} + 1.2 \times 10^3 = 5.4 \times 10^3 \, \mathrm{m\,s^{-1}}$;

(g) $t = \frac{s}{v} = \frac{4.7 \times 10^{11}}{5.4 \times 10^3} = 8.7 \times 10^7 \, \mathrm{s}$;

so total time $4.8 \times 10^7 + 8.7 \times 10^7 \, \mathrm{s} \approx 4.2 \, \mathrm{y}$;

The reminder of these answers is HL only

(The original numbering in the questions was wrong: all ”M04” should be substituted by ”M05”)

18. M05 TZ1 S1:17, H1:18 – D
19. M05 TZ1 H1:10 – A
20. M05 TZ1 H1:12 – C
21. M05 TZ1 H1:14 – B
22. M05 TZ1 H1:32 – B
23. M05 TZ1 H1:19 – PQ only
24. M05 TZ1 H1:20 – D
25. M05 TZ1 H1:23 – B (only those with antinode in the center)
26. M05 TZ1 H1:31 – D

27. M05 TZ1 H2:B4p1

(a) momentum of object $= 2\times10^3\times6.0$;
momentum after collision $= 2.4\times10^3\times v$;
use conservation of momentum, $2\times10^3\times6.0 = 2.4\times10^3\times v$;
to get $v = 5.0\,\mathrm{m\,s^{-1}}$;
Award ***[2 max]*** *for mass after collision* $= 400\,kg$ *and* $v = 30\,m\,s^{-1}$.

(b) KE of object and bar + change in PE $= 1.2\times10^3\times25 + 2.4\times10^3\times10\times0.75$;
use $\Delta E = Fd, 4.8\times10^4 = F\times0.75$;
to give $F = 64\,\mathrm{kN}$;
Award ***[2 max]*** *if PE missed,* $F = 40\,\mathrm{kN}$.
or
$a = \frac{v2}{2s}$;
$F - mg = ma$;
to give $F = 64\,\mathrm{kN}$;
Award ***[2 max]*** *if mg missed.*

(c) recognize that the height is given by $mgh = \frac{1}{2}mv^2$;

$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2.0 \times 10^3 \times 36 = 3.6 \times 10^4$ J;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3} = 5.0$ s;

or

calculation of $PE = mgh$ using $v^2 = u^2 + 2as$

$h = 1.8\,\text{m}$;

$mgh = 2.0 \times 10^3 \times 10 \times 1.8$;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3} = 5.0$ s;

(d) (i) a process in which there is no energy (heat) exchange;
between system and surrounding;
or
all the work done;
either increases or decreases the internal energy of the system;

(ii) a process that takes place at constant volume;

(iii) a process that takes place at constant pressure;

(e) (i) adiabatics: $C \rightarrow D, A \rightarrow B$;

(ii) isochoric: $D \rightarrow A$;

(iii) isobaric: $B \rightarrow C$;

(f) work done in one cycle;

(g) $\frac{8400}{40} = 210 \text{ J}$;

(h) $Eff = \frac{W}{Q_H}$;

therefore, $Q_H = \frac{210}{0.4} = 525 \text{ J}$;