M13/4/PHYSI/SP2/ENG/TZ2/XX/M

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MARKSCHEME

May 2013

PHYSICS

Standard Level

Paper 2

17 pages

Subject Details: Physics SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[25 marks]** and **ONE** question in Section B **[25 marks]**. Maximum total=**[50 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional.

2. Each marking point has a separate line and the end is shown by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are <u>underlined</u> are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect).

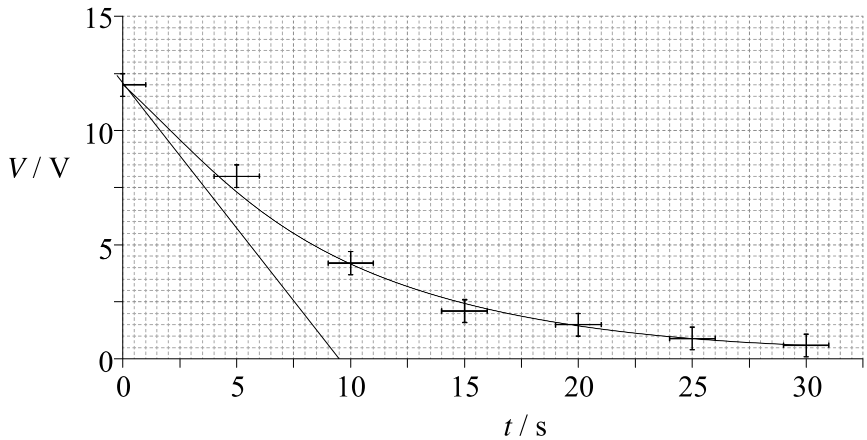
8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

SECTION A

A1. (a)



(i) smooth curve;
that passes through all error bars; ***[2]***

(ii) correctly identifies three points from own graph;
correctly processes these three using exponential/half-life/constant ratio/ relationship;
to conclude that decay is exponential;
within uncertainty; ***[4]***

(b) (i) evaluates a gradient over a minimum of 5 s to give an initial rate for example, $\left(\frac{12}{9.5}=\right)1.3\ \text{V s}^{-1}$ for graph above; } *(allow ECF from the graph)*

V s^{-1}; ***[2]***

Clear evidence of calculation of gradient must be seen.

(ii) obtains evidenced answer for t intercept; ***[1]***

(c) $C = \left(\frac{(b)(ii)}{10 \times 10^6} = \right) 1.0 \times 10^{-6}\ \Omega^{-1}\ \text{s/F}$; **[1]**

*Award **[0]** for absence of 10^6 unless unit is in terms of MΩ.*

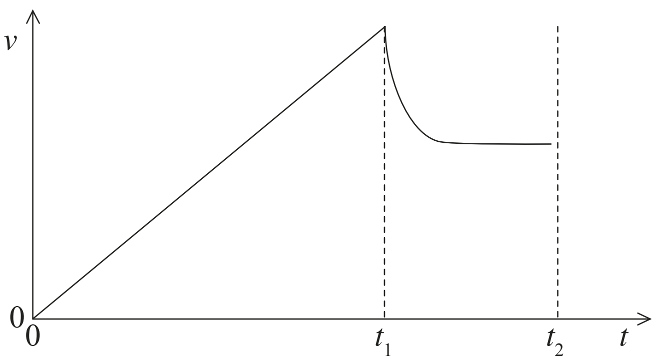
A2. (a) (i) $s = 12.5/12.6\ \text{m}$; **[1]**

(ii) $v = \sqrt{2gs}$ ***or*** gt; *(allow any use of suvat equations)*

$= \left(\sqrt{2 \times 9.8 \times 12.5} = \right) 15.7\ \text{m s}^{-1}$; **[2]**

*Award **[2]** for a bald correct answer.*

(b)

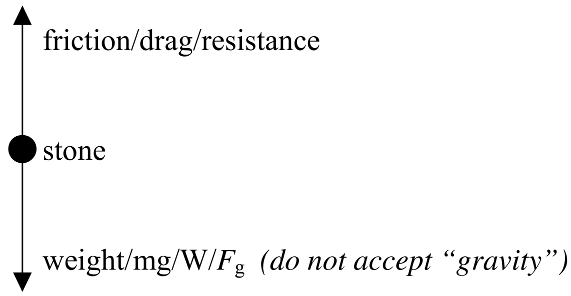


straight line to water surface;

clear decrease after hitting surface;

constant non-zero speed reached smaller than maximum; *(speed must be less than maximum velocity)* **[3]**

(c)



correctly labelled forces;
correct direction and equal lengths; *(judge by eye)* ***[2]***

A3. (a) energy output in a year $= \left(4.0\times10^{9}\times3.2\times10^{7} =\right)1.28\times10^{17}$ J ;

energy input $= \left(\dfrac{1.28\times10^{17}}{0.4} =\right)3.2\times10^{17}$ J ;

mass of coal $= \left(\dfrac{3.2\times10^{17}}{2.4\times10^{7}} =\right)1.3\times10^{10}$ kg ; ***[3]***

Allow approach using power output.

or

power required from coal $\left(=\dfrac{4.0}{0.4}\right) = 10\,\text{GW}$;

mass of coal required every second $\left(=\dfrac{10\times10^{9}}{2.4\times10^{7}}\right) = 417\,\text{kg}$;

mass of coal required every year $\left(= 417\times3.2\times10^{7}\right) = 1.33\times10^{10}$ kg ;

Allow alternative working leading to correct answer.

(b) *advantage*:
(nuclear power) does not produce carbon dioxide;
therefore it does not add to the greenhouse effect/global warming;

or

energy density of U-235 (fuel) is very high / small mass is required;
fuel is likely to last a long time/easier to transport / *OWTTE*;

disadvantage:
waste products (of U-235 fuel) are radioactive;
no safe method of disposal / long half-life; *(do not accept "lasts a long time")* ***[4]***

or

allows development of nuclear weapons;
mention of plutonium/uranium enrichment/dirty bomb;

or

accidents are potentially catastrophic;
leading to widespread mutations/cancers/contamination/other named effect;

or

power plant is more expensive;
plausible reason for the expense for example safety/complex plant/ decommissioning / *OWTTE*;

SECTION B

B1. Part 1 Nuclear reactions and radioactive decay

(a) (i) nuclides/atom/element/nucleus/nuclei that have same proton number/same element but different nucleon/neutron numbers / *OWTTE*; ***[1]***

(ii) the time taken for the activity (of a radioactive sample) to decrease by half / the time taken for half the (initial) number of radioactive nuclei/atoms/mass to decay; ***[1]***

(b) (i) 2; ***[1]***

(ii) (mass difference =) $7.0160 - [3.0161 + 4.0026] = (-)2.7 \times 10^{-3}\,\text{u}$;

(energy required =) $(-)2.7 \times 10^{-3} \times 931.5$ ***or*** $2.5151\,\text{MeV}$;

($\approx 2.5\,\text{MeV}$) ***[2]***

Allow unit conversions via mass and mc^2.

(c) 2.5MeV must be converted to mass (in the interaction) / otherwise the products would not be moving;
(to conserve momentum) final products must have total momentum equal to that of incoming neutron (so extra energy is required) / *OWTTE*; ***[2]***

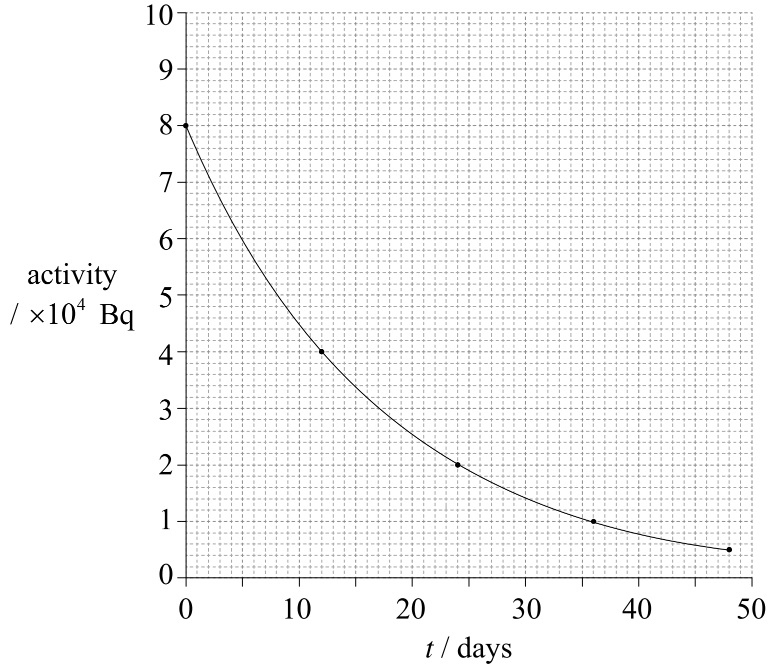
(d) ${}^{3}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + \beta^{-} + \bar{v}$

β^{-} ***or*** ${}^{0}_{-1}\text{e}$ ***or*** e^{-} ***or*** electron ***or*** beta particle;

$\bar{v}$ ***or*** ${}^{0}_{0}\bar{v}$ ***or*** antineutrino; ***[2]***

Allow answers in either order.

(e) (i)



five correct data points;
smooth curve through data points; ***[2]***

(ii) 1.4×10^{4} Bq; ***[1]***
Allow correct reading from mis-drawn graph ± 0.1.

(iii) number of atoms left $=\frac{1.2\times10^{11}\times1.4}{8}$ ***or*** uses proportion ***or*** uses $\ln\left(\frac{N}{N_0}\right)=-\lambda t$; *(with correct values)*
2.1×10^{10}; ***[2]***
*Award **[2]** for a bald correct answer.*

Part 2 Thermal concepts

(a) *internal energy*:
the sum of the potential and the (random) kinetic energy of the molecules/particles of a substance;

thermal energy:
the (non-mechanical) transfer of energy between two different bodies as a result of a temperature difference between them; ***[2]***

(b) (i) $(\Delta U) = 0.25 \times 4.2 \times 10^3 \times 27 \ (= 2.835 \times 10^4 \text{ J})$;
$= 2.8 \times 10^4 \text{ J}$; ***[2]***

(ii) energy transfer $= [300 \times 120] - [2.835 \times 10^4] = 7.65 \times 10^3 \text{ J}$;
rate of transfer $= \dfrac{7.650 \times 10^3}{120} = 64 \text{ W}$; ***[2]***
Allow ECF from (b)(i).

(c) (i) total energy supplied to water $= (500 \times 300 - 500 \times 64 =)\ 1.18 \times 10^5 \text{ J}$;
specific latent heat $= \left(\dfrac{Q}{m} = \dfrac{1.18 \times 10^5}{0.05} = \right) 2.4 \times 10^6 \text{ J kg}^{-1}$; ***[2]***
*Award **[1 max]** for* $\dfrac{500 \times \text{answer to (b)(ii)}}{0.05}$.

(ii) all the thermal energy is used to separate the molecules/break the bonds between molecules;
and not to increase their (average) kinetic energy;
average kinetic energy is a measure of the temperature (of the water); ***[3]***

B2. Part 1 Electric charge and electric circuits

(a) the force between two (point) charges;
is inversely proportional to the square of their separation and (directly) proportional to (the product of) their magnitudes; ***[2]***
*Allow **[2]** for equation with F, Q and r defined.*

(b) (i) $F = \left(k\dfrac{q_1 q_2}{r^2} =\right) \dfrac{9\times10^{9}\times[1.6\times10^{-19}]^2}{4\times10^{-20}}$;
$= 5.8\times10^{-9}\,\text{N}$; ***[2]***

(ii) $\dfrac{(b)(i)}{1.6\times10^{-19}}$ ***or*** $3.6\times10^{10}\,\text{N}\,\text{C}^{-1}$ ***or*** $\text{V}\,\text{m}^{-1}$;
(directed) away from the proton; ***[2]***
Allow ECF from (b)(i).

(iii) $H = \left(G\dfrac{m}{r^2} =\right) \dfrac{6.67\times10^{-11}\times1.673\times10^{-27}}{4\times10^{-20}} = 2.8\times10^{-18}\,\text{N}\,\text{kg}^{-1}$;
$\dfrac{H}{E} = \dfrac{2.8\times10^{-18}}{3.6\times10^{10}}$ ***or*** $7.8\times10^{-29}\,\text{C}\,\text{kg}^{-1}$;
$(\approx10^{-28}\,\text{C}\,\text{kg}^{-1})$ ***[2]***
Allow ECF from (b)(i).

(iv) 3.4 V; ***[1]***

(c) (i) power supplied per unit current / energy supplied per unit charge / work done per unit charge; ***[1]***

(ii) energy supplied per coulomb $= \frac{5.1\times10^{-19}}{1.6\times10^{-19}}$ ***or*** $3.19\,\text{V}$;

$(\approx 3.2\,\text{V})$ ***[1]***

(iii) pd across $5.0\,\Omega$ resistor $= \left(\frac{4.0\times10^{-19}}{1.6\times10^{-19}} =\right) 2.5\,\text{V}$;

pd across $r = (3.2 - 2.5 =)\; 0.70\,\text{V}$;

and

either

current in circuit $= \left(\frac{2.5}{5.0} =\right) 0.5\,\text{A}$;

resistance of $r = \left(\frac{0.70}{0.50} =\right) 1.4\,\Omega$;

or

resistance of $r = \frac{0.70}{2.5}\times 5.0$;

$= 1.4\,\Omega$;

or

$3.2 = 0.5(R + r)$;

resistance of $r = 1.4\,\Omega$; ***[4]***

Award ***[4]*** *for alternative working.*

Part 2 Momentum

(a) product of mass and velocity; *[1]*
Accept symbols if defined correctly.

(b) if the net external force acting on a system is zero;
the momentum of the system remains constant/unchanged/the same; *[2]*

or

for a closed system;
the momentum remains constant/unchanged/the same;

(c) identifies the system as rocket + exhaust gases / total momentum of rocket and gas is equal before and after; *(it must be clear that this is the system, a mention of rocket and gases is not enough)*
no external forces act on this system / closed system;
increase/change in momentum of the gases is equal and opposite to the increase/change of momentum of the rocket; *[3]*

(d) (i) attempts to use conservation of momentum, *eg* $8.0 \times 1.3 = 52 \times v$;
$v = 0.20\,\mathrm{m\,s^{-1}}$; *[2]*
*Award **[2]** for a bald correct answer.*

(ii) identifies new mass as 75.3 kg;
$V = 0.14\,\mathrm{m\,s^{-1}}$; *[2]*

B3. Part 1 Simple harmonic motion (SHM) and waves

(a) the acceleration of piston/P is proportional to its displacement from equilibrium;
and directed towards equilibrium; ***[2]***

(b) (i) 12 cm; *(accept –12)* ***[1]***

(ii) any maximum or minimum of the graph; ***[1]***

(iii) period = 0.04 s; *(allow clear substitution of this value)*

$$\omega = \left(\frac{2\pi}{T} =\right) \frac{2\times 3.14}{0.04} = 157\ \text{rad s}^{-1};$$

maximum acceleration $= (A\omega^2 =)\ 0.12\times 157^2 = 3.0\times 10^3\ \text{m s}^{-2}$;

(iv) at $t = 0.052$ s $x = (-)4(\pm 1)$ cm;

$$\text{KE} = \left(\tfrac{1}{2}m\omega^2\left[A^2 - x^2\right] =\right) 0.5\times 0.32\times 157^2\,[0.12^2 - 0.04^2] = 50\,(\pm 7)\ \text{J};$$ ***[2]***

Allow ECF from (b)(iii).
Allow use of sin ωt *to obtain v.*
Award ***[2]*** *for a bald correct answer.*

(c) (i) the direction of the oscillations/vibrations/movements of the particles (in the medium/gas);
for a longitudinal wave are parallel to the direction of the propagation of the energy of the wave; ***[2]***

(ii) $$f = \left(\frac{1}{T} =\right) \frac{1}{0.04} = 25\ \text{Hz};$$

$$\lambda = \left(\frac{v}{f} =\right) \frac{340}{25} = 14\ \text{m};$$ ***[2]***

Allow ECF from (b)(iii).

Part 2 Wind power and the greenhouse effect

(a) power output of a turbine $= 0.3 \times \frac{1}{2}\rho A v^3 = 0.3 \times 0.5 \times 1.2 \times 3.14 \times [42]^2 \times [12]^3$ $(= 1723\,\text{kW})$;

number of turbines needed $= \dfrac{4 \times 10^9}{1.723 \times 10^6}$ $(= 2322)$;

area needed $= 2322 \times 5.0 \times 10^4$;

$= 1.2 \times 10^8\ \text{m}^2$; ***[4]***

(b) *look for these main points*:
the surface of Earth re-radiates the Sun's radiation;
greenhouse gases (in atmosphere) readily absorb infrared;
mention of resonance;
the absorbed radiation is re-emitted (by atmosphere) in all directions;
(some of) which reaches the Earth and further heats the surface; ***[3 max]***

(c) (i) total absorbed radiation $=$ total emitted radiation $= 238\ \text{W m}^{-2}$;

temperature of Earth $= \left[\dfrac{238}{5.67 \times 10^{-8}}\right]^{\frac{1}{4}} = 255\ \text{K}$; ***[2]***

(ii) total absorbed radiation at surface $= 238 + \left[\left(\varepsilon\sigma T^4\right) 0.78 \times 5.67 \times 10^{-8} \times 250^4\right]$;

$= 410.8\ \text{W m}^{-2}$;

temperature of surface $= \left[\dfrac{410.8}{5.67 \times 10^{-8}}\right]^{\frac{1}{4}} = 291.7\ \text{K}$;

$\approx 292\ \text{K}$ ***[3]***