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Mark Scheme (Results)

Summer 2012

GCE Physics (6PH05) Paper 01
Physics from Creation to Collapse

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**1**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see ‘wtte’ (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. ‘resonance’

1.2 Bold lower case will be used for emphasis.

1.3 Round brackets ( ) indicate words that are not essential e.g. “(hence) distance is increased”.

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 Incorrect use of case e.g. ‘Watt’ or ‘w’ will **not** be penalised.

2.3 There will be no unit penalty applied in ‘show that’ questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).

2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in ‘show that’ questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

3.2 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] [Bald answer scores 0, reverse calculation 2/3]	✓	**3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

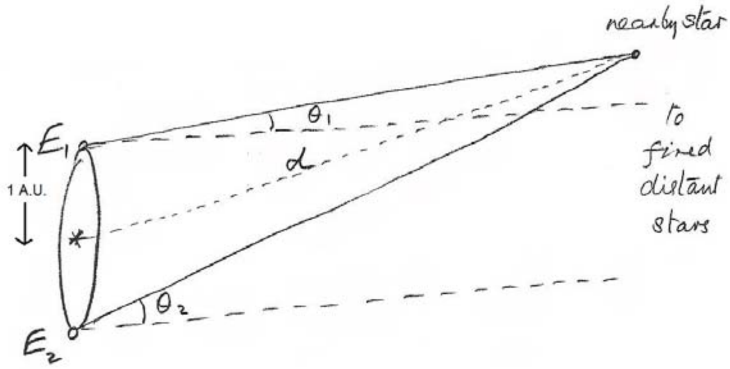
Question Number	Answer	Mark
1	D	**1**
2	B	**1**
3	D	**1**
4	B	**1**
5	C	**1**
6	A	**1**
7	D	**1**
8	D	**1**
9	B	**1**
10	B	**1**

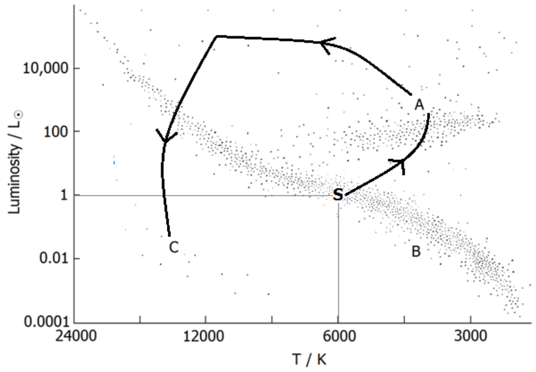
Question Number	Answer	Mark
11	**MAX 3** The existence of the microwave background: • Originates from the Big Bang **(1)** • Microwave radiation comes from the universe itself **Or** it is <u>cosmic background</u> radiation [accept CMB] **(1)** • Microwave wavelength linked to temperature of universe [e.g. indicates a temperature of space of about 3 K] **(1)** • Originally the universe was a hotter place than it is now **Or** temperature decreases as the universe expands **(1)** • Wavelength has been increased Or frequency decreased. (Do not credit changes due to movement of galaxies) **(1)**	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12(a)	Use of $\Delta E = mc\Delta\theta$ **(1)** Energy = 780 J **(1)** <u>Example of calculation</u> $\Delta E = 34\times10^{-3}\,\text{kg}\times490\,\text{J kg}^{-1}\text{K}^{-1}\times(100-53)\text{K} = 783\,\text{J}$	**2**
12(b)	Heat / thermal energy is transferred from the sphere to the wax **(1)** Idea that the lead sphere has insufficient energy for melting the wax (e.g. The lead sphere transfers less heat / thermal energy (than the steel sphere). Credit a supporting calculation) **(1)**	**2**
	Total for question 12	**4**

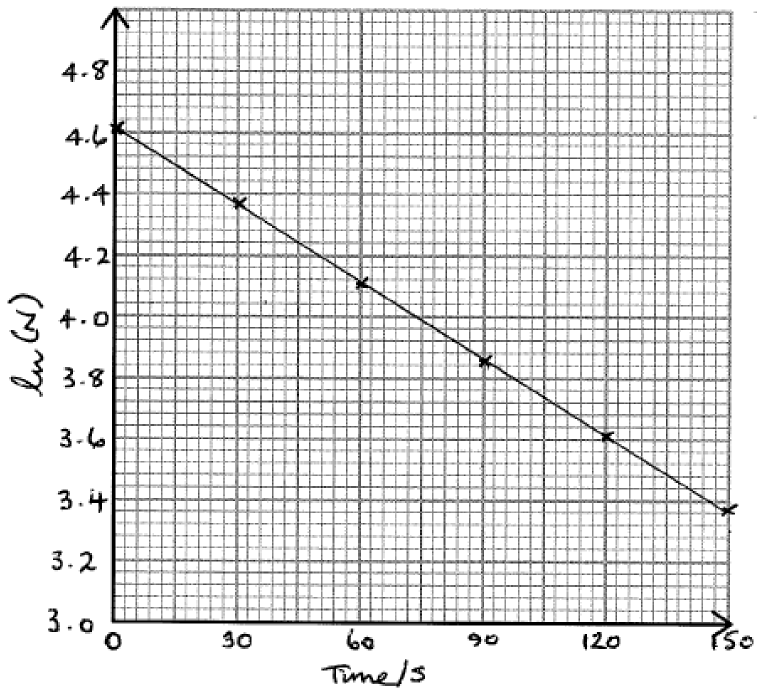
Question Number	Answer	Mark
13(a)(i)	16 μm [accept ±1μm] **(1)**	**1**
13(a)(ii)	Use of $\lambda_{max}T = 2.898 \times 10^{-3}$ **(1)** Temperature = 180 K (ecf from (a)(i)) **(1)** [161 K for 18 μm, 170 K for 17 μm, 193 K for 15 μm, 207 K for 14 μm] <u>Example of calculation</u> $T = \frac{2.898 \times 10^{-3}\ \text{mK}}{16 \times 10^{-6}\ \text{m}} = 181\text{K}$	**2**
13(b)	Mass of the Sun **(1)** G **Or** gravitational constant **Or** 6.67×10^{-11} ($\text{N m}^2\ \text{kg}^{-2}$) **(1)** [can be next to either answer prompt]	**2**
13(c)	Use of $g = \frac{GM}{r^2}$ **(1)** Field strength = 5.6×10^{-6} N kg^{-1} [accept m s^{-2}] **(1)** <u>Example of calculation</u> $g = \frac{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 1.9 \times 10^{27}\ \text{kg}}{(1.5 \times 10^{11}\ \text{m})^2} = 5.63 \times 10^{-6}\ \text{N kg}^{-1}$	**2**
	Total for question 13	**7**

Question Number	Answer		Mark
14(a)	Use of $pV = NkT$ Number of molecules = 2.2×10^{23} (Use of the number of molecules to get a pressure of 0.99×10^5 Pa can score both marks. Allow use of pV = nRT leading to correct answer for 2 marks, but no credit for a substitution of incorrect values into this equation) Example of calculation $N = \dfrac{1.1 \times 10^5 \text{ Pa} \times 8.2 \times 10^{-3} \text{ m}^3}{1.38 \times 10^{-23} \text{ J K}^{-1} \times 295 \text{ K}} = 2.2 \times 10^{23}$	**(1)** **(1)**	 **2**
14(b)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **(For this question accept answers in terms of atoms, molecules or particles)** • Internal energy is (sum of) molecular kinetic and potential energies • In (an ideal) gas the molecules have only kinetic energy **Or** the molecules do not have potential energy. • $E_k = 3kT/2$ **Or** $E_k \propto T$ **Or** (above 0 K) the air molecules are in (continual) random motion • If the gas reached absolute zero, then the K.E. of the molecules would be zero and so the statement is correct **Or** If air is identified as not being ideal, then allow idea that molecules would still have potential energy at 0 K, and so statement is incorrect	 **(1)** **(1)** **(1)** **(1)**	 **4**
	Total for question 14		**6**

Question Number	Answer	Mark
15(a)	**Max 2** • Angles are measured using the fixed background of more distant stars **(1)** • Find angular displacement of the star (as Earth moves around the Sun) over a 6 month period / over a diameter of the Earth's orbit **(1)** • Diameter of the Earth's orbit about the Sun must be measured/known **(1)** [Full marks can be obtained from an annotated diagram] 	**2**
15(b)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate Idea that red shift is the (fractional) increase in wavelength of light received **(1)** (due to) recession of the source from the Earth/observer **(1)** Doppler/red shift is used to find *v* (allow reference to use of red shift equation e.g. $v = zc$) **(1)** Appropriate reference to Hubble's Law **Or** $v = H_O d$ **(1)** [for 1st marking point allow "decrease in frequency" for "increase in wavelength"]	**4**
	Total for question 15	**6**

Question Number	Answer	Mark
16(a)(i)	A = Red Giants **Or** Giants **(1)** B = Main Sequence **(1)** C = White Dwarfs **Or** Dwarfs **(1)**	**3**
16(a)(ii)	 S → A correctly marked (straight line or curve starting at S going near A) **(1)** **(1)** A → C correctly marked (some upward curving from near A, near to C but can go beyond C)	**2**
16(b)	We determine the star's • temperature T (from Wien's law) **(1)** • luminosity L (from the H-R diagram) **(1)** • (Then) r is calculated using (Stefan's Law) $L=4\pi r^2\sigma T^4$ **Or** $L=A\sigma T^4$ **(1)** [accept a re-arranged equation for A **Or** r]	**3**
	Total for question 16	**8**

Question Number	Answer		Mark
17(a)(i)	Resonance	**(1)**	**1**
17(a)(ii)	The vibrations from the engine/road surface/wheels must drive/force the tiger's head (to vibrate) at a frequency equal/close to its natural frequency **Or** Driver/forcing frequency Matches natural frequency	**(1)** **(1)** **(1)** **(1)**	**2**
17(b)(i)	Use of $\omega = \frac{2\pi}{T}$ Use of $a_{max} = \omega^2 A$ Amplitude = 2×10^{-2} m <u>Example of calculation</u> $\omega = \frac{2\pi}{0.8\ s} = 7.85\ (rad)s^{-1}$ $A = \frac{1.2\ ms^{-2}}{(7.85\ s^{-1})^2} = 1.95 \times 10^{-2}\ m$	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	Correct shape and phase (in antiphase with acceleration) for graph Amplitude (ecf from (b)(i)) **and** a time marked on axes	**(1)** **(1)**	**2**
	Total for question 17		**8**

Question Number	Answer		Mark
18(a)	**Max 4 with at least ONE similarity and ONE difference** **Similarities**: • Radioactive decay and corn popping are both random events **Or** the time at which any given nucleus will decay **and** any kernel will pop cannot be predicted **Or** can't tell which nucleus will decay **nor** which kernel will pop next • (With a large number) the rate of decay / popping for both depends upon the number of unchanged nuclei / kernels • Both have a decreasing rate of decay • The rate of decay / popping depends upon the type of nucleus (isotope) / size of kernel • Radioactive decay is an irreversible change, as is corn popping **Differences:** • Not all the kernels are identical, whereas (for a given isotope) all the nuclei are identical • Popping of corn depends on external factors and radioactive decay does not. (examples such as heating acceptable) • The kernels do not emit standard fragments when they decay whereas radioactive nuclei emit radiation.	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
18(b)(i)	Log graph drawn Suitable scales [not starting from 0 on y-axis] Correct plotting of 6 points Valid attempt at gradient calculation Use of $t_{1/2}$ = ln 2/gradient $t_{1/2}$ = 82 ± 3 s <u>Example of Calculation</u> 	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**

$$gradient = \frac{(4.4 - 3.4)}{(26 - 145)\,s} = 8.4 \times 10^{-3} s^{-1}$$

$$t_{1/2} = \frac{0.693}{8.4 \times 10^{-3} s^{-1}} = 82\ s$$

Or [Max 4]

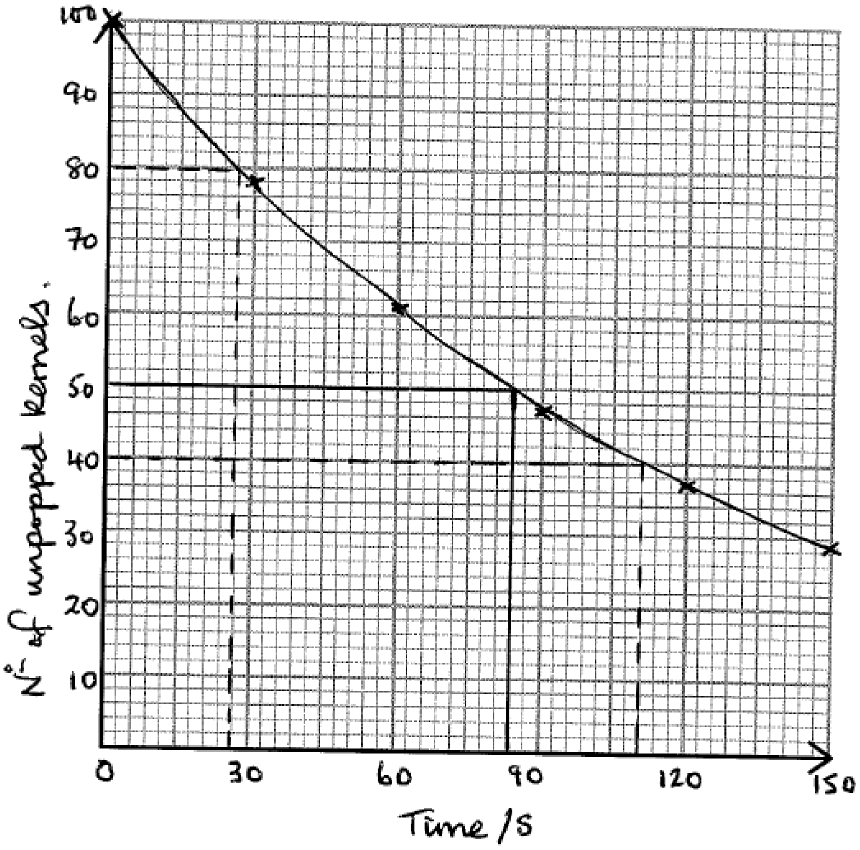
Suitable scales **(1)**

Correct plotting **(1)**

$t_{1/2}$ = 82 ± 3 s accurate from their graph **(1)**

Half life found from curve for at least two initial values of N **(1)**

<u>Example of calculation</u>



$t_{½}$ = (84 – 0) s = 84 s

$t_{½}$ = (111 – 27) s = 84 s

18(b)(ii)

(Identify that ¼ of kernels **or** 25 kernels are left, so 2 half lives have elapsed)

2 × answer in (i) **Or** read from graph **Or** 160 s **(1)**

<u>Example of calculation</u>

$$N = 100 - 75 = 25 \therefore \frac{N}{N_0} = \frac{25}{100} = \frac{1}{4}$$

t = 2 × 82 s = 164 s

	Total for question 18	**11**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>19(a)</td><td>Similarity: Same number of protons Or same magnitude of charge Or both have 1 proton (1)

Difference: Different number of neutrons / nucleons Or different mass Or D has 1 neutrons and T has 2 neutrons (1)</td><td>2</td></tr>
<tr><td>19(b)</td><td>Use of $P = \frac{\Delta E}{\Delta t}$ (do not penalise a power of ten error) (1)
Energy = 7.5×10^6 (J) (1)

<u>Example of calculation</u>
$E = 500 \times 10^{12}\ \text{W} \times 15 \times 10^{-9}\ \text{s} = 7.5 \times 10^6\ \text{J}$</td><td>2</td></tr>
<tr><td>19(c)(i)</td><td>$^{2}_{1}\text{D} + {}^{3}_{1}\text{T} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}\text{n}$

<table><tr><td>Top line</td><td>2</td><td>3</td><td>4</td><td>1</td></tr><tr><td>Bottom line</td><td>1</td><td>1</td><td>2</td><td>0</td></tr></table>(1)
(1)</td><td>2</td></tr>
<tr><td>19(c)(ii)</td><td>Attempt at calculation of mass difference (1)
Energy released = 17.5 (MeV) [17.5 must be clearly identified as an energy] (1)

<u>Example of calculation</u>
Δm= (1875.6 + 2808.9 – 3727.4 – 939.6) MeV/c^2 = 17.5 MeV/c^2
ΔE = 17.5 MeV</td><td>2</td></tr>
<tr><td>19(c)(iii)</td><td>Conversion of energy to consistent units (1)
Number of nuclei = 3×10^{18} (1)

<u>Example of calculation</u>
In each fusion $\Delta E = 17.5 \times 10^6\ \text{eV} \times 1.6 \times 10^{-19}\ \text{J eV}^{-1} = 2.8 \times 10^{-12}\ \text{J}$
$\therefore N = \frac{7.5 \times 10^6\ \text{J}}{2.8 \times 10^{-12}\ \text{J}} = 2.68 \times 10^{18}$
<table><tr><th>Energy MJ (b)</th><th>Energy MeV (c)(ii)</th><th>N × 10^{18}</th></tr><tr><td>7.5</td><td>17.5</td><td>2.7</td></tr><tr><td>7.5</td><td>20</td><td>2.3</td></tr><tr><td>8</td><td>17.5</td><td>2.9</td></tr><tr><td>8</td><td>20</td><td>2.5</td></tr></table></td><td>2</td></tr>
</table>

19(c)(iv)	Application of momentum conservation **(1)** Deduction that $V_N = 4\ V_\alpha$ [$v_N = 3.967\ v_\alpha$] **(1)** Use of $E_K = \frac{1}{2}mv^2$ (ratio as shown **or** sum = 17.5 MeV) **(1)** Energy = 14 MeV (ecf (c)(ii), 14.1 MeV, if $v_N = 3.967\ v_\alpha$ 16 MeV if 20 MeV used) **(1)** **Or** Application of momentum conservation **(1)** Use of $E_k = p^2/2m$ **(1)** Deduction that $E_N = 4\ E_\alpha$ **(1)** Energy = 14 MeV **(1)** <u>Example of calculation (1st method)</u> $m_N V_N = m_\alpha V_\alpha$ $V_N = \frac{m_\alpha}{m_N} \times V_\alpha = 4V_\alpha$ $\frac{E_N}{E_\alpha} = \frac{\frac{1}{2}m_N V_N^2}{\frac{1}{2}m_\alpha V_\alpha^2} = \frac{1}{4} \times \left(\frac{4}{1}\right)^2 = 4$ $\therefore E_N = \frac{4}{5} \times 17.5\text{ MeV} = 14\text{ MeV}$ <u>Example of calculation (2nd method)</u> $p_\alpha = p_N$ $p_\alpha^2 = p_N^2$ $E_\alpha \times 2m_\alpha = E_N \times 2m_N$ $\therefore E_\alpha = E_N \times \frac{m_N}{m_\alpha} = \frac{E_N}{4}$ Also, $E_\alpha + E_N = 17.5\text{ MeV}$ $\therefore \frac{E_N}{4} + E_N = 17.5\text{ MeV}$ $\therefore E_N = \frac{4}{5} \times 17.5\text{ MeV} = 14\text{ MeV}$	4
19(d)	**Max 3** A heavy **nucleus** absorbs a neutron. [accepts "collides with" / "fired into" for "absorbs"] **(1)** The **nucleus** becomes unstable **and** splits into two (roughly equal sized) fragments [accept "decays" / "breaks up" for "splits"] **(1)** Idea that a few neutrons are also emitted in the fission process **(1)** These neutrons cause further fissions **Or** these neutrons cause a chain reaction **(1)** (if atom is used instead of nucleus **only penalise once**)	3
	Total for question 19	**17**

Total marks for this paper = 80

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