A-LEVEL
PHYSICS
7408/2

Paper 2

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional Comments/Guidance	Mark	ID details
01.1	Total energy supplied (= *Pt*) = $12 \times 890 = 10\,680$ (J) ✓1 Heat energy to evaporate nitrogen at its boiling point (= ml) = $0.05 \times 2.0 \times 10^5 = 10\,000$ (J) ✓2 (Use of $Q = mc\Delta\theta$) Attempt to use $c = \left(\frac{Q}{m \times \Delta\theta}\right) = \frac{(10680-10000)}{0.050 \times (77-70)}$ ✓3 specific heat capacity of liquid nitrogen = $c = 1.9 \times 10^3$ ✓4 (allow 1 sig fig due to the small temperature difference) $J\ kg^{-1}\ K^{-1}$ or $J\ kg^{-1}\ {}^{o}C^{-1}$ ✓5 {taken from the answer line but if not present can come from the body of the answer space}	✓1 Substitution or answer. ✓2 Substitution or answer. ✓3 Allow any attempt at substitution with (77 – 70) or 7 correct but ΔQ does not have to be correct so can even show an addition. ✓4 Allow 1 sig fig due to the small temperature difference. No ecf – correct answer only. ✓5 Correct answer Consistent with 4th mark and only in the form shown ie no double or single solidus/oblique lines. Only penalise the kelvin unit if it has an obvious loop at the top – allow if simply small.	5	AO1-1b-2 AO2-1d-3 Math2-4
01.2	(Use of volume = $\frac{m}{\rho}$) nitrogen gas = $\frac{0.050}{3.8} = 0.013\ (m^3)$ ✓1 {if both given both must be correct} nitrogen liquid = $\frac{0.050}{810} = 0.000062\ (m^3)$ OR a reference to the volume being negligible ✓2 Work done in expanding (= X = $p\Delta V$) $= 1.0 \times 10^5 \times 0.013 = 1.3 \times 10^3$ (J) ✓3	✓1 Substitution or answer and can be seen without label or explanation. ✓2 Substitution or answer or words. ✓3 Evidence of ΔV or calculation introduced with 'work done =' is required for the mark. For an ecf the product must be shown in full with the substitution of the ecf being clear. ✓4 Allow ecf from 01.1 for this mark provided	4	AO1-1a-1 AO2-1f-1 AO3-1b-2 Math2-1

	which is less than 1.0×10^4 J/the energy to change state =Y (ie X<Y) ✓4	the statement is consistent with the figures. OR If the ecf comes from the 3rd mark above then the work done in expanding must be clearly labelled for the comparison or have units of J i.e it cannot be compared with a number that just happens to be on the page.		

Total			**9**

Question	Answers	Additional Comments/Guidance	Mark	ID details
02.1	It is the <u>sum/total</u> of the (kinetic and potential) energies of the <u>particles/atoms/molecules</u> (that move at random in the gas) ✓1 For reference to kinetic energy of the gas or molecules ✓2	✓1 Cannot be an average or a rms energy. Nor a vague reference to an energy of or in the gas. ✓2 This is independent of the first mark provided energy of the gas is given in some form. So here an average kinetic energy would be acceptable.	2	AO1-1a-2
02.2	(Using) the gas laws it is the temperature at which the volume/pressure of a gas extrapolates to zero OR (Using *pV* = *nRT* or *pV* = *NRT*) it is the temperature when *pV* or *V* or *p* is zero OR Plotting data of volume (or pressure) against temperature the plot extrapolates and crosses the temperature axis at absolute	✓1first Condone 'becomes/is zero' or phrases like 'said to be zero' or 'thought to be zero'. ✓1second Just quoting Charles' law or the Pressure law is not enough. ✓1third Allow the information in the form of a sketch.	2	AO1-1a-2

	zero OWTTE ✓1 (whereas) using the kinetic energy it is the temperature at which the (random) motion stops or can be extrapolated to stop or the kinetic energy (of the particles) is zero. ✓2	✓2 The zero must be very explicit e.g. not just very very small. Allow reference to zero point energy/residual kinetic energy at 0 K/uncertainty at 0 K		

Question	Answers	Additional Comments/Guidance	Mark	ID details
02.3	Mass of argon atom = $\frac{\text{molar mass}}{N_A}$ $= \frac{4.0\times10^{-2}}{N_A} = \frac{4.0\times10^{-2}}{6.02\times10^{23}} = 6.6(4)\times10^{-26}$ (kg) ✓1 $c_{rms} = \left(\frac{3kT}{m}\right)^{1/2}$ $= \left(\frac{3\times1.38\times10^{-23}\times310}{6.64\times10^{-26}}\right)^{1/2}$ ✓2 {*k* can be in form of a symbol} = 440 (m s^{-1}) ✓3 Alternative 1 $\frac{m(c_{rms})^2}{2}$ or $(E_k)_{average} = \left(\frac{3kT}{2}\right) = \frac{3RT}{2N_A}$ ✓1Alt1 $c_{rms} = \left(\frac{3RT}{mN_A}\right)^{1/2} = \left(\frac{3\times8.31\times310}{4.0\times10^{-2}}\right)^{1/2}$ ✓2Alt1 {*R* can be in form of a symbol} = 440 (m s^{-1}) ✓3Alt1	✓1 Substitution of the molar mass or the answer gains the mark. Also the numbers may be seen in the equation of the second mark. ✓2 Give a mark for this rearrangement and substitution even if the mass is incorrect. c_{rms} must be the only unknown in the equation, data and constants to be shown. ✓3 Only allow a correct answer so no ecf from the second mark. A correct answer gains all three marks ✓1Alt1 The Mark is for introducing $\frac{R}{N_A}$ in the mean energy equation. ✓2Alt1 The mark is for the use of the molar mass. c_{rms} must be the only unknown in the equation, data and constants to be shown. ✓3Alt1 Only allow a correct answer so no ecf	3	AO1-1b-1 AO2-1f-2 Math2-3

	Alternative 2 $(E_k)_{average} = \frac{3kT}{2} = \frac{3 \times 1.38 \times 10^{-23} \times 310}{2} = 6.42 \times 10^{-21}$ (J) OR $(E_k)_{total} = (E_k)_{average} \times N_A = 6.42 \times 10^{-21} \times 6.02 \times 10^{23}$ $(E_k)_{total} = 3.86 \times 10^3$ (J) ✓1Alt2 $c_{rms} = \left(\frac{2 \times (their\ energy)}{\text{molar mass}}\right)^{1/2} = \left(\frac{2 \times (E_k)_{total}}{\text{molar mass}}\right)^{1/2}$ $= \left(\frac{2 \times 3.86 \times 10^3}{4.0 \times 10^{-2}}\right)^{1/2}$ ✓2Alt2 = 439 (m s^{-1}) ✓3Alt2	from the second mark. A correct answer gains all three marks {On most occasions answer 5.7×10^{-10} m s^{-1} yields 2 marks as the wrong mass has been used} ✓1Alt2 The mark can be given for evaluating either the average or the total kinetic energy. ✓2Alt2 Give a mark for this rearrangement and substitution even if the energy is incorrect. c_{rms} must be the only unknown in the equation, data and constants to be shown. ✓3Alt2 Only allow a correct answer so no ecf from the second mark. A correct answer gains all three marks {On most occasions answer 5.7×10^{-10} m s^{-1} yields 2 marks as the wrong mass has been used} Note the slightly different answers for the third mark which depends on the route taken.		

02.4	(In equilibrium at the same temperature) both gases have the same <u>mean or average</u> kinetic energy ✓	Allow 'they are the same' as a bold statement. However if this is not an opening statement following the question then 'mean or average' must be used.	1	AO2-1d-1 Math2-1

02.5	Particles/atoms/molecules collide with the piston/walls and change momentum ✓1 (The piston provides the) force = <u>rate of change</u> of momentum	✓1 Ignore any reference to particles colliding with each other.	3	AO1-1b-2 AO2-1b-1

	or <u>impulse</u>(*Ft*) = change in momentum ✓$_2$			
	(The particles give a force on the piston producing a pressure) A relevant reference to pressure = force divided by/over area or *F*/*A* ✓$_3$	✓$_3$ Relevant = reference to Piston or arising from the particles. (ie where or what) If no mark is scored give a mark for *P* = *F*/*A* alone		

Question	Answers	Additional Comments/Guidance	Mark	ID details
02.6	**change** the volume could be increased **explanation** which increases the <u>time between collisions</u> OR <u>results in less frequent collisions</u> (with the piston/wall so reducing the rate of change of momentum) OR which increases the area of the piston/wall (and so reduces the pressure) **change** the temperature could be reduced **explanation** which reduces the momentum (change at the wall) OR (and) increases the time between collisions or reduces the frequency of collisions (reducing the rate of change of momentum) ✓✓✓	An explanation in terms of the gas laws is not acceptable. **3 marks** for 2 changes and 2 explanations **2 marks** for 2 changes and 1 explanation **1 mark** for 1 change with corresponding explanation OR 2 changes with no adequate explanation If a wrong change is given, eg. reduce the mass, then only one mark is available for one change with corresponding explanation.	3	AO2-1h-2 AO3-1a-1
Total			**14**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.1	the work done/energy <u>required</u> in bringing <u>1 kg/unit</u> mass from infinity to the point ✓	A test mass should not be taken to be a unit mass. Ignore extra comments eg about charge.	1	AO1-1a-1
03.2	The potential difference between the lines is constant but the distances are not Or $\frac{\Delta V}{\Delta r}$ is changing ✓ (potentials $\frac{\Delta V}{\Delta r}$, inner 0.857, outer = 0.625) Or The equipotential surfaces are not straight / not parallel / are curved ✓	The mark is given for the idea that the separation should be uniform or that equipotential lines should not be curved. Owtte Discussions should not imply there is a correct curvature. Errors can come from references to the moon to first equipotential distance. Or by saying the potential gaps are not uniform or by saying the distance from the centre of the Moon is not proportional to the potential.	1	AO3-1a-1
03.3	M = mass of Moon $= \frac{-\mathrm{V}\times\mathrm{r}}{\mathrm{G}} = \frac{(-1)\times -1.60\times10^{6}\times3.06\times10^{6}}{6.67\times10^{-11}}$ ✓$_1$ M = 7.3 or 7.4 × 10^{22} (kg) ✓$_2$ (Use of $\frac{GMm}{\mathrm{r}} = \frac{1}{2}mv^2$) $v = \sqrt{\frac{2GM}{r}}$ ✓$_3$	✓$_1$ The mark is given for use and rearranging the equation so errors may be seen in the data and any equipotential may be used. Condone the misuse of a negative sign ✓$_2$ Note All equipotential lines produce the same mass. The answer my be seen in the equations that follow. ✓$_2$ An attempt to use this re-arranged formula gains this 3rd mark.	4	AO3-1b-1 AO2-1f-3 Math2-2

	$v = 2.3$ or 2.4×10^3 (m s^{-1}) ✓$_4$ (2370 m s^{-1})			

	Alternative (Use of $V = \frac{-GM}{r}$) $Vr = -MG$ = constant $Vr = -1.60 \times 10^6 \times 3.06 \times 10^6$ $= -4.9 \times 10^{12}$ (J Kg^{-1} m) ✓$_{1Alt}$ (at the surface of the Moon) $V_{surface} = \frac{-4.9 \times 10^{12}}{1.74 \times 10^6}$ $V_{surface} = -2.8(2) \times 10^6$ (J kg^{-1}) ✓$_{2Alt}$ (Use of $mV = \frac{1}{2}mv^2$) $v = \sqrt{2V_{surface}} = \sqrt{2 \times 2.82 \times 10^6}$ ✓$_{3Alt}$ $v = 2.4 \times 10^3$ (m s^{-1}) ✓	✓$_{1Alt}$ Any attempt to calculate Vr OR to indicate that it is constant gains this mark. ✓$_{3Alt}$ An attempt to use this re-arranged formula gains this 3rd mark. ✓$_{4Alt}$ A correct answer shows the previous work has been done correctly and gains all 4 marks.		

Total			**6**

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.1	C (= $4\pi\varepsilon_o r = 4\pi \times 8.85 \times 10^{-12} \times 0.020$) = $2.2(2) \times 10^{-12}$ (F) ✓1 V (= Q/C) = $52 \times 10^{-9}/2.22 \times 10^{-12}$ ✓2 V = 23 000 (V) ✓3 (23 400 V)	✓1 Mark for substitution or answer. Also it may be seen incorporated into the second mark. Substitution of ✓2 Use of r = 0.04 m in the previous mark is treated as an arithmetic error and the substitution $52 \times 10^{-9}/4.44 \times 10^{-12}$ is given a CE mark. ✓3 A continuation of the CE gives a mark to the answer 12000 or 11700 (V) A correct answer gains all 3 marks. Commonly 23000 V gives 3 marks 11700 V gives 2 marks Also a power of 10 error in the final answer gives 2 marks. For any other final answer the only possibility is to get one mark for use of $V = Q/C$ when C is clearly given or $V = \frac{Q}{4\pi\varepsilon_o r}$ is uses with an incorrect value of r.	3	AO1-1a-1 AO2-1d-1 Math2-1

04.2	Labelled arrows on **B** • Tension or T parallel to thread and upwards • weight or *mg* or W starting from sphere centre vertically down • electrostatic force or repulsion to right and starting from the inside or edge of the sphere ✓✓ 2 marks for all 3 arrows and labels 1 mark for 2 arrows and labels 1 mark for 3 arrows, no or incomplete labels	For the electrostatic force label also allow F_{elec} or 'force between charges. F_A etc. Ignore gravity between spheres. If a reaction force given – max 1 mark.	2	AO1-1c-2

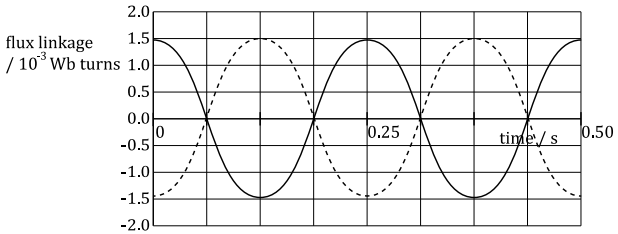
04.3	One mark for stating the problem. $\checkmark_1$ One mark for giving a corresponding solution. $\checkmark_2$ For example Metallic or conducting instruments placed between the spheres will affect the separation (because of the movement of charge/electrons within the instrument) (Inside) calipers made from a non-conduction material in conjunction with a ruler could be used Or A travelling telescope on a vernier scale could be used (at a distance) Other examples of problems Physically touching the spheres may alter the reading. Difficulty of measuring distance between curved objects. A measuring instrument can have a dielectric constant/permittivity, which will affect the separation/disrupt the field. Reading a ruler behind the spheres will give rise to a parallax error.	$\checkmark_1$ The problem must be explicitly stated but not much detail is needed. EG Anything used between the spheres my disrupt the field. $\checkmark_2$ The solution must be detailed enough to convey what must happen. Other examples of solutions. Ruler and set square set up parallel to the line joining the centres of the spheres. Measure (beforehand) the length of thread *y* and measure the angle with a protractor and calculate distance x using trig'.		AO2-1c-2

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.4	Using distance = $80\ \text{mm}$ (mark given even in a wrong formula) Or Stating that the charge can be considered to be in the centre of each sphere ✓1 $F\ (=\frac{Q_1Q_2}{4\pi\varepsilon_o r^2}) = \frac{\left(52\times10^{-9}\right)^2}{4\pi\varepsilon_o(0.080)^2}$ ✓2 $F = 3.8\times10^{-3}$ (N) ✓3 (Showing at least 2 sig figs)	✓2 Power of 10 errors are condoned and so is the use of the wrong separation (as this was penalized in the previous mark). ✓3 No ecf for this final mark.	3	AO1-1a-1 AO2-1f-1 Math2-2
04.5	(As each sphere is in equilibrium then $\tan\theta = \frac{F_{\text{electrostatic}}}{mg}$ a mark is given for a reference and substitution into this equation in any configuration. The second mark is for an evaluation that is said to be consistent. Use of 4×10^{-3} N given in **04.4** gains full credit.) $\theta = \tan^{-1}\left\{\frac{3.8\times10^{-3}}{3.2\times10^{-3}\times9.8}\right\}$ ✓= 6.9^o which is consistent ✓ or $F_{\text{electrostatic}} = \left\{3.2\times10^{-3}\times\ 9.8\times\tan 7^o\right\}$ ✓ $= 3.8(5)\times10^{-3}$ (N) which is consistent ✓ or $m = \left\{\frac{3.8\times10^{-3}}{9.8\tan 7^o}\right\}$ ✓ $= 3.1(6)\times10^{-3}$ (kg) which is consistent ✓ Alternatively $T = \frac{3.2\times10^{-3}\times9.8}{\cos 7^o} = 0.032$ ✓1Alt and $T = \frac{3.8\times10^{-3}}{\sin 7^o} = 0.031$, the same value so consistent ✓2Alt	using 4×10^{-3} N gives 7.3^o More circular routes using Pythagoras are possible but they end in the same calculated results. using 4×10^{-3} N gives $3.3(2)\times10^{-3}$ kg ✓1Alt Any equation that results in the calculation	2	AO2-1f-2 Math2-2

		of the tension. $\checkmark_{2Alt}$ A second calculation of the tension which is stated to be consistent with the first.		

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.6	(In the following calculations condone the use of 1 sig fig for all data) $F_{grav}(=\frac{GMm}{r^2}) = 6.67 \times 10^{-11} \times \frac{(3.2\times10^{-3})^2}{0.080^2}$ ✓1a $F_{grav} = 1.1 \times 10^{-13}$ (N) which is small/negligible compared to F_{elect} ($\approx 4 \times 10^{-3}$ N) so statement is valid ✓2a **Alternative** (find the ratio between the forces) $(\frac{F_{elec}}{F_{grav}} = \frac{\frac{Q_1Q_2}{4\pi\varepsilon_o r^2}}{\frac{GMm}{r^2}})$ $\frac{F_{elec}}{F_{grav}} = \left(\frac{Q_1Q_2}{Mm}\right)\frac{1}{G4\pi\varepsilon_o}$ (mark given for this ratio or the substitution below) $\frac{F_{elec}}{F_{grav}} = \left(\frac{(52\times10^{-9})^2}{(3.2\times10^{-3})^2}\right) \times \left(\frac{1}{6.67\times10^{-11}\times4\times\pi\times8.85\times10^{-12}}\right)$ ✓1b F_{elec} is 3.6×10^{10} times F_{grav} OR or F_{grav} is 2.8×10^{-11} times F_{elec} ✓2b	✓1a It is the use of the formula that is important for the mark. Giving the equation in symbols followed by an answer gains the mark. ✓2a No ecf for the second mark in order to keep the same level of difficulty as in the alternative.	2	AO3-1a-2 Math2-2

Total			14

Question	Answers	Additional Comments/Guidance	Mark	ID details
05.1	$N = \frac{\Phi}{AB}$ Or $N = \frac{1.5 \times 10^{-3}}{2.5 \times 10^{-2} \times 5.0 \times 10^{-4}}$ ✓1 N = 120 (turns) ✓2	✓1 *N* must be the subject of the equation for the mark. ✓2 A correct answer gains both marks. If no mark is awarded a single mark can be given for $\Phi = BAN\cos 30^{o}$ being used to find *N* =139.	2	AO1-1a-1 AO2-1f-1 Math2-1
05.2	$\Phi\left(= \text{NAB}\cos\theta = 1.5 \times 10^{-3}\cos 30^{o}\right)$ Flux linkage = 1.3×10^{-3} (Wb turns) ✓		1	AO2-1f-1 Math2-1
05.3	$f = \frac{1}{T} = \frac{1}{0.25}$ = 4.0 (Hz) or ω = 25.1 or 8π (rad s^{-1}) ✓1 Peak emf (= $BAN\frac{2\pi}{T}$= $1.5 \times 10^{-3} \times \frac{2\pi}{0.25}$) = 0.038 (volt) ✓2 (0.0377 volt)	✓1 Condone using 1 sig fig for *f* but not ω or *T*. The mark can be gained from seeing *f* or ω or *T* given explicitly or from a substitution in the peak emf equation in the second mark. ✓2 A correct answer gains both marks.	2	AO1-1a-1 AO2-1h-1 Math2-2
05.4	 Either solid or dashed line gains mark ✓	The mark is dependent on the exact crossing of the time axis which has a tolerance of ± 1 small square. The vertical axis figures is not expected. Also ignore errors in height and the exact positions of the peaks. Only a rough sinusoidal shape is expected. A	1	AO3-1a-1 Math2-1

		triangular shape with very slightly rounded edges would be acceptable.		

Total			**6**

Question	Answers	Additional Comments/Guidance	Mark	ID details
06.1	To increase the probability/chance of fission (when neutron collides with fissile material/ U-235) Or To allow the neutron to be absorbed by the fuel/U-235 ✓	Condone because thermal/slow moving neutrons are needed for fission to take place 'fuel' but not 'fuel rod' to be used in the alternative. Reject inaccurate descriptions for example ones that imply the neutrons are undergoing fission.	1	AO2-1a-1
06.2	$E_{final} = (1 - 0.63)\ E_{incident}$ or $E_{final} = 0.37\ E_{incident}$ ✓1 (continuing this idea, $E_1 = (1 - 0.63)\ E_0$ $E_2 = (1 - 0.63)\ E_1$ so $E_2 = (1 - 0.63)^2\ E_0$ and $E_5 = (1 - 0.63)^5\ E_0$ $E_5 = (1 - 0.63)^5 \times 2.0 \times 10^6$)) $= 1.4 \times 10^4$ eV ✓2 (1.39×10^4 eV)	If no marks are scored a single mark can be given: if the final answer that has a power of 10 error possibly by not using the M in the eV. OR using 0.63 rather than (1 – 0.63) in the calculation giving the answer $2(.0) \times 10^5$ (eV) ✓2 A correct final answer gains full marks	2	AO2-1b-1 AO2-1f-1 Math2-2
06.3	A link made between the change in kinetic energy or	✓1 Ref. to mass is needed. {Essence of marking point: The mass	2	AO2-1g-1

	momentum to the masses of the (two) particles involved in the collision. ✓1 A consistent argument that results in a statement 'as nucleon number/number of nucleons in the nucleus increases more collisions are required. ✓2	determines how much KE/momentum is lost} ✓2 Ref to nucleon number or equivalent needed but mass is not. {Essence of marking point: If N is high then not much KE is lost so more collisions are needed} An example of an argument could be: More (kinetic) energy is lost when the mass of the moderator atom/nucleus is closer to the mass of the neutron So the number of collisions needed increases with nucleon number		AO3-1a-1

Question	Answers	Additional Comments/Guidance	Mark	ID details
06.4	Mass difference = ($mass_U$ + $mass_n$) – ($mass_{Xe}$ + $mass_{Sr}$ + 4 $mass_n$) = (235.044 + 1.0087) – (141.930 + 89.908 + 4 × 1.0087) ✓1 = 0.180 u ✓2 {if no unit present take u as the default unit} (= 0.180 × 931.5) = 168 (MeV) ✓3	✓1 Mark for word equation or substitution, one neutron may be cancelled from both parts of the subtraction. Condone any simple slip in transferring the numbers. Also the mark can be awarded for giving or comparing the mass on the LHS with the RHS. ✓2 Only allow correct answer. ✓3 This mark can stand alone for the conversion of any number of u converted to MeV. 2 sig figs is acceptable. The conversion mark can come from any part of this question not just the final line. {1 kg = 6.02 x 10^{26}} A correct answer gains all 3 marks.	3	AO2-1f-3 Math2-1
06.5	1. (Small amounts of fossil fuel used) so <u>little</u> greenhouse gas emissions/less global warming/less CO_2/less climate change. {not <u>no</u> greenhouse gas} 2. (Less fossil fuel used) so cleaner air. 3. Small amounts of fuel consumed to get the same/large amount of power/energy. 4. Nuclear power can be produced continuously{condone use of constant} (whereas renewables are dependent on sunlight/wind etc). 5. Some (but not all) nuclear power stations can adjust their output quickly. 6. Benefit of producing medical isotopes.	Just one of the examples may be from the following: At present nuclear fuel is obtained from stable allied countries (as opposed to oil/gas). Facilitates nuclear weapon production. (Less fuel used) so less transportation needed. Examples of rejected ideas because they are incomplete or wrong: Produces more energy. There is more uranium than fossil fuel. Damages the environment less. Provides jobs. More efficient than others.	3	AO1-1a-1 AO3-1a-2

	✓✓✓any three points	Reference to cost. It's a renewable source.		

Total			**11**

	Keys to Objective Test Questions (each correct answer is worth 1 mark)												
Qu	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Ans	**C**	**B**	**B**	**C**	**D**	**C**	**A**	**B**	**D**	**D**	**D**	**D**	**A**
Qu	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
Ans	**C**	**C**	**B**	**B**	**C**	**C**	**D**	**A**	**B**	**D**	**B**	**C**	