Mark Scheme (SAM)

Pearson Edexcel International Advanced Level in Physics

Unit 5: Physics from Creation to Collapse

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.

Further notes

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.

Mark scheme format

1. You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the mark scheme has specified specific words that must be present. Such words will be indicated by underlining, e.g. '<u>resonance</u>'.
2. Bold lower case will be used for emphasis.
3. Round brackets ( ) indicate words that are not essential, e.g. '(hence) distance is increased'.
4. Square brackets [ ] indicate advice to examiners or examples, e.g. [Do not accept gravity] [ecf].

Unit error penalties

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. Incorrect use of case, e.g. 'Watt' or 'w' will **not** be penalised.
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.
4. The same missing or incorrect unit will not be penalised more than once within one question (one clip in e-pen).
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.
6. The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

1. Use of an inappropriate number of significant figures (sf) 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.
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}.

Calculations

1. Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
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.
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. **Recall** of the correct formula will be awarded when the formula is seen or implied by substitution.
5. The mark scheme will show a correctly worked answer for illustration only.
6. Example of mark scheme for a calculation:

'Show that' calculation of weight Use of L × W × H Substitution into density equation with a volume and density Correct answer [49.4 (N)] to at least 3 significant figures [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] 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	 ✓ ✓ ✓	**(3)**

Quality of Written Communication

1. Indicated by 'Quality of Written Communication' in the mark scheme. Work must be clear and organised in a logical manner using technical wording where appropriate.
2. Usually it is part of a maximum mark, the final mark not being awarded unless the Quality of Written Communication condition has been satisfied.

Graphs

1. A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
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.
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.
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.
5. For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Section A

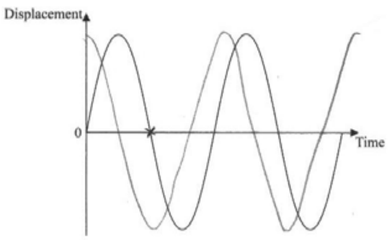
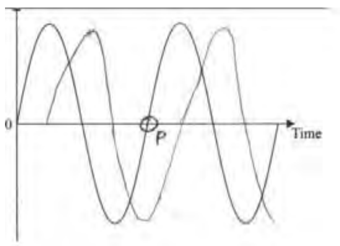
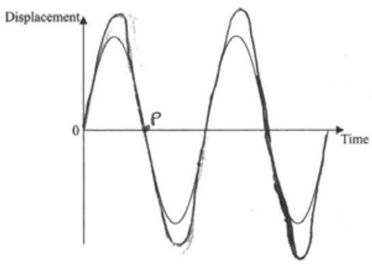
Question Number	Answer	Mark
1	D	(1)
2	B	(1)
3	C	(1)
4	B	(1)
5	B	(1)
6	D	(1)
7	C	(1)
8	C	(1)
9	B	(1)
10	D	(1)

Total for Section A = 10 Marks

Section B

Question Number	Answer		Mark
11	There is a red shift [accept Doppler shift]. The galaxy is receding **or** the galaxy is moving away from us [Do not accept 'the universe is expanding'.]	(1) (1)	(2)
	Total for Question 11		**(2)**

Question Number	Answer		Mark
12(a)	Use of electrical power equation, e.g. $P = (V)^2/R$ $R = 8.8\ \Omega$ [Use of V=IR and P=VI gains mp1] <u>Example of calculation</u> $R = \frac{(230V)^2}{6000W} = 8.82\Omega$	(1) (1)	(2)
12(b)	See 30 K [30 ^{o}C] **Or** 6000 J s^{-1} Use of $\Delta E = mc\Delta\theta$ [do not penalise wrong temperature conversions, but $\Delta\theta$ must be a temperature difference]. $\frac{\Delta m}{\Delta t} = 0.048\,\mathrm{kg\,s^{-1}}$ [accept 0.048 litre s^{-1} and other volume flow rates with correct units] <u>Example of calculation</u> $\Delta\theta = (37.5 - 7.5)\ ^{o}C = 30\ ^{o}C$ $\frac{\Delta m}{\Delta t} = \frac{6000\,\mathrm{W}}{4200\,\mathrm{J\,kg^{-1}\,K^{-1}} \times 30\,\mathrm{K}} = 0.0476\,\mathrm{kg\,s^{-1}}$	(1) (1) (1)	(3)
	Total for Question 12		**(5)**

Question Number	Answer	Mark
13(a)	Pendulum C has same/similar length as pendulum X **(1)** Therefore C has the same/similar <u>natural</u> frequency as pendulum X **(1)** **Or** idea that C is driven at its <u>natural</u> frequency (Hence) the energy transfer from X to C is most efficient **Or** There is a maximum transfer of energy from X to C **Or** A correct reference to resonance **(1)**	**(3)**
13(b)	Any zero displacement point marked on original graph [do not insist on 'P'] **(1)** (Minus) cosine graph drawn with same period as original graph **(1)** [Ignore amplitude of graph drawn] Examples of graphs:  This candidate has identified 'P' (although not used 'P') and the cosine graph is well drawn. [2 marks]  This candidate has identified 'P' correctly, and has drawn a minus cosine graph. Their graph starts from a time of T/4, which is just about acceptable. [2 marks]  This candidate has identified 'P' correctly, but has drawn a sine curve. [1 mark]	**(2)**
	Total for Question 13	**(5)**

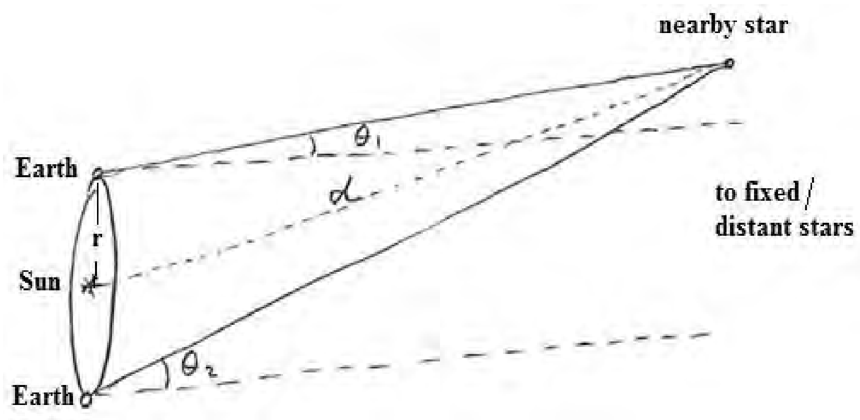
<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*14</td><td>
(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate.)

Parallax:
The star is viewed from two positions at 6 month intervals or the star is viewed from opposite ends of its orbit diameter about the Sun (1)

The (change in) angular position of the star relative to fixed/distant stars is measured (1)

The diameter/radius of the Earth's orbit about the Sun must be known and trigonometry is used (to calculate the distance to the star) [do not accept Pythagoras] (1)

The marks above may be obtained with the aid of a suitably annotated diagram, e.g



[Accept the symmetrical diagram seen in many textbooks]

Standard candle:
Flux/brightness/intensity of standard candle is measured (1)

Luminosity of standard candle is known [accept reference to absolute magnitude or total power output of star] (1)
Inverse square law is used (to calculate distance to standard candle) (1)
</td><td>(6)</td></tr>
<tr><td></td><td>Total for Question 14</td><td>(6)</td></tr>
</table>

Question Number	Answer		Mark
15(a)	Use of $F = \frac{G m_1 m_2}{r^2}$ G = 6.6×10^{-11} (N m^2 kg^{-2}) [must see 6.6×10^{-11} when rounded to 2 sf] <u>Example of calculation</u> $G = \frac{1.5 \times 10^{-7}\,\text{N} \times (0.23\,\text{m})^2}{160\,\text{kg} \times 0.75\,\text{kg}} = 6.61 \times 10^{-11}\,\text{N}\,\text{m}^2\,\text{kg}^{-2}$	**(1)** **(1)**	**(2)**
15(b)(i)	Read (peak) times from graph for at least 3 cycles T = 6.4 min (±0.2 min) [T = (380 ±12) s] [Maximum 1 mark if correct answer shown without working] <u>Example of calculation</u> $T = \frac{(28.0 - 2.5)\text{ min}}{4} = 6.38\text{ min}$	**(1)** **(1)**	**(2)**
15(b)(ii)	Air resistance acts on the sphere [accept frictional forces **or** (viscous) drag for air resistance] Energy is removed from the oscillation/system **Or** the oscillation/system is damped [For mp 2 do not credit 'energy is lost' but accept 'energy is dissipated'; answer must indicate idea of transfer of energy]	**(1)** **(1)**	**(2)**
15(b)(iii)	Evidence of values of at least 3 consecutive peaks read from graph [accept values of 3 points separated by equal time intervals] Attempt to obtain amplitudes, by subtracting 0.75 Calculation of two values of A_{n+1}/A_n with corresponding conclusion **Or** Calculation of two values of difference of ln A_{n+1} and ln A_n with corresponding conclusion **Or** Use peaks of graph to sketch curve Use curve to determine 'half-life' [accept other ratio] Calculation of two values of 'half-life' with corresponding conclusion <u>Example of calculation</u> A_0 = 1.45-0.75 = 0.7, A_1 = 0.75-0.25 = 0.5, A_2 = 1.1-0.75 = 0.35, A_4 = 0.75 – 0.5 = 0.25 $\frac{A_1}{A_0} = \frac{0.50}{0.70} = 0.71$ $\frac{A_2}{A_1} = \frac{0.35}{0.50} = 0.70$ $\frac{A_3}{A_2} = \frac{0.25}{0.35} = 0.71$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**(3)**
	Total for Question 15		**(9)**

Question Number	Answer		Mark
16(a)	Temperature (of gas) [treat references to oil/room as neutral] Mass of air/gas **or** number of atoms/molecules/moles of air/gas [accept amount of air/gas, number of particles of air/gas]	**(1)** **(1)**	**(2)**
16(b)	Assumption: idea that volume occupied by trapped air ∝ length of air in tube [e.g. volume = cross-sectional area × length] pL = a constant [accept pV = a constant] **or** if p doubles, L halves At least 2 pairs of p, L values correctly read from graph Readings show that pL = 4500 (kPa cm) [± 100 kPa cm] **Or** readings show that p doubles when L is halved [Accept references to V instead of L] <u>Example of calculation</u> p = 400 kPa, L = 11.0 cm pL=400 × 11.0 = 4400 p = 200 kPa, L = 23.0 cm pL=200 × 23.0 = 4600	**(1)** **(1)** **(1)** **(1)**	**(4)**
16(c)	Use of $pV=NkT$ [Allow use of pV=nRT **and** $N=n.N_A$] Conversion of temperature to kelvin $N = 8.4 \times 10^{20}$ [Accept answers in range 8.1×10^{20} to 8.4×10^{20}] [Answer in range but with an incorrect temperature conversion score maximum 2] <u>Example of calculation</u> $N = \dfrac{450 \times 10^3\ \text{Pa} \times 0.10\ \text{m} \times 7.5 \times 10^{-5}\ \text{m}^2}{1.38 \times 10^{-23}\ \text{JK}^{-1} \times (273+20)\text{K}} = 8.35 \times 10^{20}$	**(1)** **(1)** **(1)**	**(3)**
16(d)(i)	No change	**(1)**	**(1)**
16(d)(ii)	Similar curve Shifted higher **or** shifted to the right [an annotated diagram can score full marks]	**(1)** **(1)**	**(2)**
	Total for Question 16		**(12)**

Question Number	Answer	Mark
17(a)(i)	Reverse direction for temperature [at least 2 values seen] **(1)** Logarithmic/power temperature variation [at least 3 realistic values seen increasing by the same factor] **(1)**	**(2)**
***17(a)(ii)**	(Quality of Written Communication – work must be clear and organised in a logical manner using technical wording where appropriate) **Area 1: maximum 2** The Sun is fusing/burning hydrogen (into helium in its core) **(1)** When (hydrogen) fusion/burning ceases the core of the Sun cools [accept radiation pressure drops when fusion/burning ceases in the core] **(1)** The core collapses/contracts (under gravitational forces) **(1)** **Area 2: maximum 2** The Sun expands and becomes a red giant **(1)** The core becomes hot enough for helium fusion/burning to begin (in the core) **(1)** Helium begins to run out and the core collapses again (under gravitational forces) **(1)** **Area 3: maximum 2** Idea that outer layers of Sun are ejected into space **(1)** The temperature doesn't rise enough for further fusion to begin **(1)** The core/Sun becomes a (white) dwarf star **(1)**	**(6)**
17(b)(i)	Idea of a very high temperature [accept value of about 10^7 K] **(1)** To overcome repulsive/electrostatic forces between protons/nuclei **Or** so that protons/nuclei get close enough together for the strong (nuclear) force to act **Or** so that protons/nuclei get close enough to fuse **(1)** Idea of a very high density [accept pressure] to give a sufficient collision rate **(1)**	**(3)**
17(b)(ii)	Attempt at calculation of mass deficit **(1)** Use of $\Delta E = c^2 \Delta m$ **(1)** Attempt at conversion from J to (M)eV **(1)** $\Delta E = 12.9$ (MeV) **(1)** [If correct mass defect in kg is converted into u and then 1u = 931 Mev used, then full marks may be awarded.] <u>Example of calculation</u> $\Delta m = ((5.008238 \times 2) - 6.646483 - (1.673534 \times 2)) \times 10^{-27}\,\text{kg}$ $\Delta m = 2.2925 \times 10^{-29}\,\text{kg}$ $\Delta E = (3.00 \times 10^8\,\text{ms}^{-1})^2 \times 2.2925 \times 10^{-29}\,\text{kg} = 2.063 \times 10^{-12}\,\text{J}$ $\Delta E = \dfrac{2.063 \times 10^{-12}\,\text{J}}{1.60 \times 10^{-13}\,\text{J MeV}^{-1}} = 12.9\,\text{MeV}$	**(4)**
	Total for Question 17	**(15)**

Question Number	Answer		Mark
18(a)(i)	Use of $\lambda.t_{1/2} = \ln 2$ $\lambda = 5.8 \times 10^{-8}$ (s^{-1}) Use of $\frac{\Delta N}{\Delta t} = -\lambda N$ $\frac{\Delta N}{\Delta t} = (-)1.5 \times 10^{8}$ Bq [accept s^{-1} **or** counts s^{-1}] <u>Example of calculation</u> $\lambda = \frac{0.693}{(138 \times 24 \times 3600)s} = 5.81 \times 10^{-8} s^{-1}$ $\frac{\Delta N}{\Delta t} = -5.81 \times 10^{-8} s^{-1} \times 2.54 \times 10^{15} = -1.48 \times 10^{8}$ Bq	(1) (1) (1) (1)	(4)
18(a)(ii)	Use of $N = N_0 e^{-\lambda t}$ Fraction of nuclei remaining = 0.90 10% of nuclei have decayed [accept 0.1 **or** 1/10] <u>Example of calculation</u> t = 21 × 24 × 3600 s = 1 814 400 s $\frac{N}{N_0} = e^{-5.81 \times 10^{-8} s^{-1} \times 1.81 \times 10^{6} s}$ $\frac{N}{N_0} = e^{-0.105} = 0.900$ Fraction decayed = 1- 0.9 = 0.1	(1) (1) (1)	(3)
18(b)	Idea that α-particles are not able to penetrate the (dead layer of) skin (from outside the body) Damage/danger if energy is transferred to cells/DNA **Or** damage/danger to cells/DNA due to ionisation	(1) (1)	(2)
18(c)(i)	$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + ^{4}_{2}\alpha$ Top line correct Bottom line correct	(1) (1)	(2)
18(c)(ii)	So that momentum is conserved	(1)	(1)
18(d)	Spontaneous means that the decay cannot be influenced by any external factors. Random means that we cannot identify which atom/nucleus will (be the next to) decay **Or** we cannot identify when an individual atom/nucleus will decay **Or** we cannot state exactly how many atoms/nuclei will decay in a set time **Or** we can only estimate the fraction of the total number that will decay in the next time interval.	(1) (1)	(2)
18(e)	Idea that traces of the isotope will be excreted from the body (and deposited in the surroundings). Idea that the half life is long enough for the activity to be detectable for a long time.	(1) (1)	(2)
	Total for Question 18		**(16)**

Total for Section B = 70 Marks

Total for Paper = 80 Marks