TB *[103 marks]*

1.

[1 mark]

Markscheme

B

Examiners report

[N/A]

2.

[1 mark]

Markscheme

B

Examiners report

[N/A]

3.

[1 mark]

Markscheme

A

Examiners report

[N/A]

4.

[1 mark]

Markscheme

C

Examiners report

[N/A]

5a.

[3 marks]

Markscheme

energy supplied/bonds broken/heat absorbed;

increases potential energy;

no change in kinetic energy (so no change in temperature);

Examiners report

[N/A]

5b.

[4 marks]

Markscheme

use of $M \times 4.2 \times 10^3 \times \Delta\theta$
$ml = 75 \times 10^{-3} \times 3.3 \times 10^5$ / 24750 J;
recognition that melted ice warms and water cools to common final temperature;
3.4ºC;

Examiners report

[N/A]

6a.

[3 marks]

Markscheme

use of area under the curve;

each (1 cm × 1 cm) square has energy of 250 J ***or*** each small square has energy of 10 J;

estimate (14 to 16 × 250) = 3500 to 4000 J;

Examiners report

[N/A]

6b.

[3 marks]

Markscheme

clear use of value on AB; (*must see correct values*)

use of $PV = nRT$;

0.56 to 0.60 mol;

Examiners report

[N/A]

6c.

[2 marks]

Markscheme

entropy unchanged;
gas returned to original state;

Examiners report

[N/A]

7.

[1 mark]

Markscheme

D

Examiners report

[N/A]

8.

[1 mark]

Markscheme

B

Examiners report

The quartz oscillator is explicitly mentioned in the guide (4.3.6). But even a holistic understanding of the role and nature of damping would lead to the elimination of A, B and C – all of which the candidates should be familiar with.

9.

[1 mark]

Markscheme

C

Examiners report

There is evidence of much guessing in this question and it elicited a few adverse comments from the teachers. But both A and B are logically equivalent so must be wrong. As an adiabatic expansion involves no thermal exchange with the surroundings, this will not affect the entropy of the local surroundings. Hence C must be correct by elimination.

10a.

[2 marks]

Markscheme

power/energy per second emitted proportional to surface area;
and proportional to fourth power of absolute temperature / temperature in K;
Accept equation with symbols defined.

Examiners report

The Stefan-Boltzmann law was poorly understood with few candidates stating that the absolute temperature is raised to the fourth power.

10b.

[2 marks]

Markscheme

solar power given by $4\pi R^2\sigma T^4$;
spreads out over sphere of surface area $4\pi d^2$;
Hence equation given.

Examiners report

This question was poorly done with few candidates substituting the surface area of the sun or the surface area of a sphere at the Earth's radius of orbit.

10c.

[2 marks]

Markscheme

$\left(\frac{\sigma R^2 T^4}{d^2} = \right) \frac{5.7\times10^{-8}\times\left[7.0\times10^{8}\right]^2\times\left[5.8\times10^{3}\right]^4}{\left[1.5\times10^{11}\right]^2}$;

$=1.4\times10^3 (Wm^{-2})$;

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

Examiners report

Despite not being able to state or manipulate the Stefan-Boltzmann law most candidates could substitute values into the expression and calculate a result.

10d.

[2 marks]

Markscheme

some energy reflected;
some energy absorbed/scattered by atmosphere; depends on latitude;
depends on time of day;
depends on time of year;
depends on weather (*eg* cloud cover) at location; power output of Sun varies;
Earth-Sun distance varies;

Examiners report

This question was well answered at higher level.

10e.

[2 marks]

Markscheme

power radiated = power absorbed;

$T = \sqrt[4]{\frac{240}{5.7\times10^{-8}}} = (250\text{K})$;

Accept answers given as 260 (K).

Examiners report

To show the given value there is the requirement for an explanation of why the incident power absorbed by the Earth's surface is equal to the power radiated by the Earth, few candidates were successful in this aspect. Although most could substitute into the Stefan-Boltzmann equation they needed to either show that the fourth root was used or to find the temperature to more significant figures than the value given.

10f.

[3 marks]

Markscheme

radiation from Sun is re-emitted from Earth at longer wavelengths; greenhouse gases in the atmosphere absorb some of this energy; and radiate some of it back to the surface of the Earth;

Examiners report

A surprising number of candidates could not explain the greenhouse effect. A common misunderstanding was that the Earth reflected radiation into the atmosphere and that the atmosphere reflected the radiation back to the Earth.

10g. *[2 marks]*

Markscheme

the force (of the spring on the object)/acceleration (of the object/point O) must be proportional to the displacement (from the equilibrium position/centre/point O);
and in the opposite direction to the displacement / always directed towards the equilibrium position/centre/point O;

Examiners report

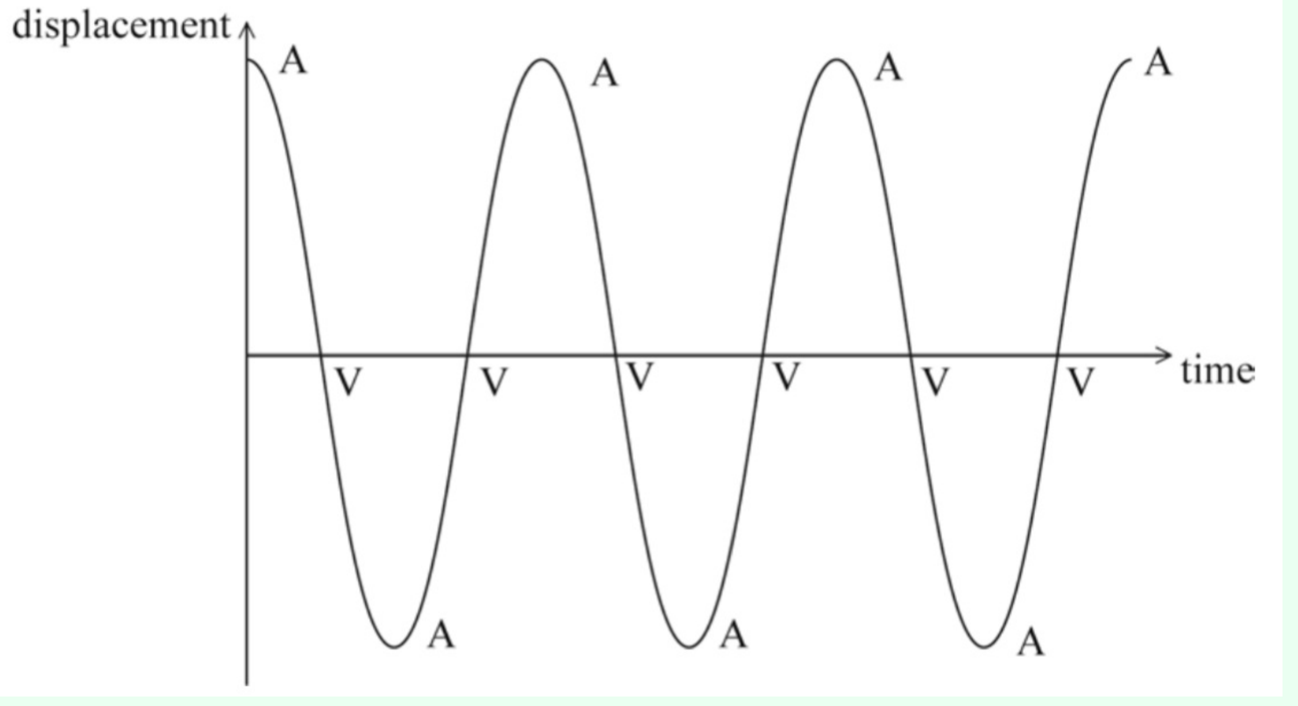
The conditions for simple harmonic motion were poorly outlined by most candidates. Few identified a relationship between force/acceleration and displacement, with most talking about it going backwards and forwards without slowing down.

10h. *[4 marks]*

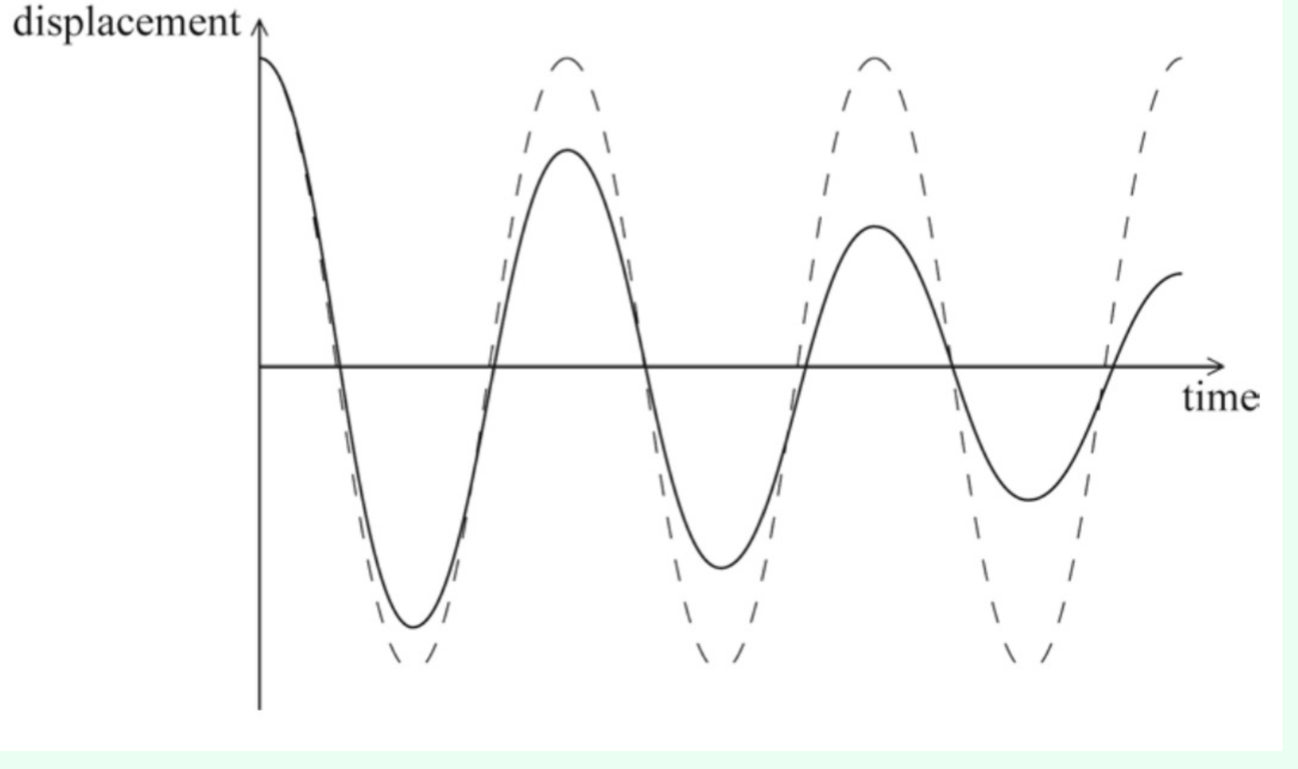
Markscheme

(i) one A correctly shown;

(ii) one V correctly shown;



(iii) same period; *(judge by eye)*
amplitude decreasing with time;



Examiners report

This question was well answered by many. The only notable mistake was with reducing the time period of the damped oscillation.

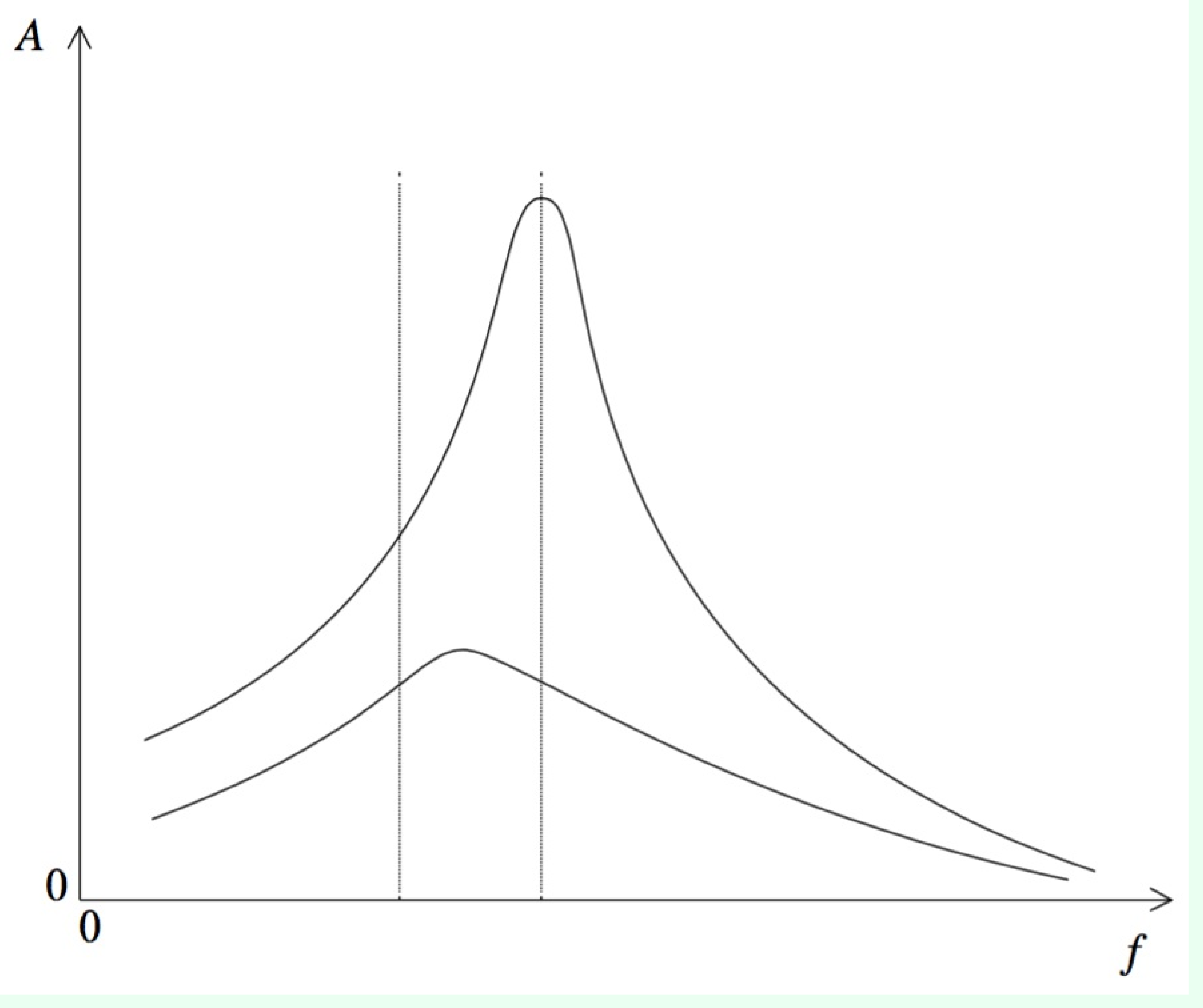
10i.

[4 marks]

Markscheme

(i) resonance is where driving frequency equals/is close to natural/resonant frequency;
the natural/resonant frequency is at/near the maximum amplitude of the graph;

(ii) lower amplitude everywhere on graph, bit still positive;
maximum in same place/moved slightly *(that is, between the lines)* to left on graph;



Examiners report

i) Identifying the peak of the graph with the resonant frequency was broadly successfully done but not many candidates stated that this occurs when the driving frequency is equal to the natural frequency.

ii) This sketch was generally well done.

11a.

[4 marks]

Markscheme

(i) a process in which temperature remains constant;

(ii) calculation to show that $pV = 16(\times 10^2)$ at any point from A to B;
calculation to show that $pV = 16(\times 10^2)$ at any other point from A to B;
pV is constant;

Examiners report

ei) Most recognized the meaning of isothermal.

eii) The calculations were successfully done but some candidates missed a concluding statement.

11b.

[1 mark]

Markscheme

isochoric / isovolumetric / occurs at constant volume;

Examiners report

This was well answered.

11c.

[2 marks]

Markscheme

$\Delta U = 0$;
Q=W=550(J);

Examiners report

A significant number attempted a calculation based on the area under the graph on the previous page.

11d.

[3 marks]

Markscheme

the gas/system must return to original conditions (*P*, *V*, and *T*);
(to do that) some of the thermal energy absorbed by gas must be given off to the surroundings;
hence not all thermal energy absorbed by gas can be converted to work;
it is the second law of thermodynamics;

Examiners report

Many were able to relate this to the second law of thermodynamics and recognized that some of the thermal energy was given off to the surroundings.

12.

[1 mark]

Markscheme

A

Examiners report

[N/A]

13.

[1 mark]

Markscheme

C

Examiners report

[N/A]

14.

[1 mark]

Markscheme

C

Examiners report

[N/A]

15.

[1 mark]

Markscheme

D

Examiners report

[N/A]

16.

[1 mark]

Markscheme

D

Examiners report

There were two aspect to this – adiabatic means no thermal energy transfer (ruling out A and B); expansion means work done on the surroundings and loss of internal energy to do the work. D is the only response matching this.

17.

[1 mark]

Markscheme

B

Examiners report

[N/A]

18.

[1 mark]

Markscheme

C

Examiners report

[N/A]

19.

[1 mark]

Markscheme

B

Examiners report

[N/A]

20. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

21. *[1 mark]*

Markscheme

D

Examiners report

22. *[1 mark]*

Markscheme

D

Examiners report

There were many comments on this question from the teachers, ranging from it being unfair to it being impossible. The physics of the situation is clear, though. The process is adiabatic, as there is no thermal energy transfer involved. It is also reversible. Hence there is no change of entropy either in the gas or the surroundings (Entropy change = $\Delta Q/T$). Alternatively it can be argued that the total entropy cannot decrease, hence, by elimination, D must be the best answer. This question is covered by the syllabus item 10.3.3 and was deemed fair.

23a. *[3 marks]*

Markscheme

(i) low pressure;
high temperature;

(ii) no thermal/heat energy is transferred (in change of state);
Allow "heat energy" but not "heat".

Examiners report

(i) Some candidates simply repeated the information they had already supplied in A4(a) without thinking the problem through afresh. The correct ideas of low pressure and high temperature were commonly seen in scripts.
(ii) Many recognized that adiabatic changes involve no energy interchange. Those who talked about no exchange of heat were penalized. The bald term "heat" is not awarded credit in this examination.

23b. *[4 marks]*

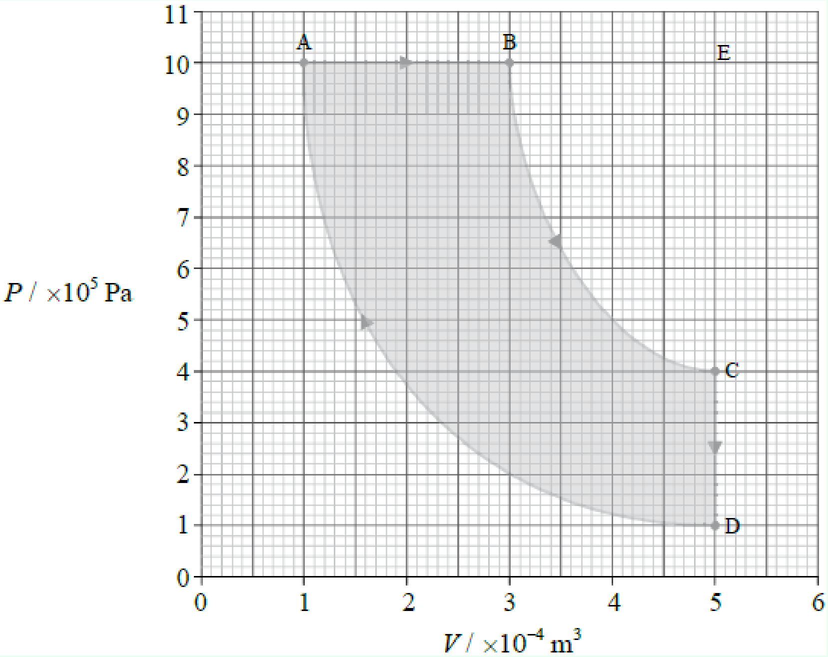
Examiners report

This was often well done with perhaps a third of the candidates gaining full or near-full marks for recognition of the work done and a deduction from this of the sign of ΔU and W.

23c.

[3 marks]

Markscheme



total work done = enclosed area / number of large squares ~40(±5);
1 square=5 J;
work done=200J (±25) J;

Examiners report

Although about half were able to arrive at a close estimate of the work done in the cycle, sometimes explanations were brief and obscure. A string of numbers without explanation does not endear itself to the examiners who can only rarely give credit to partial solutions if it is not clear what ideas are in use or where the data is coming from.

24.

[1 mark]

Markscheme

A

Examiners report

25.

[1 mark]

Markscheme

A

Examiners report

26. *[1 mark]*

Markscheme

D

Examiners report

27a. *[1 mark]*

Markscheme

the maximum displacement of the system from equilibrium/from centre of motion / *OWTTE*;

Examiners report

27b. *[5 marks]*

Markscheme

(i) the amplitude of the oscillations/(total) energy decreases (with time); because a force always opposes direction of motion/there is a resistive force/ there is a friction force;
Do not allow bald "friction".

(ii) $\omega = \sqrt{\frac{2g}{l}}$;

$T = 2\pi\sqrt{\frac{0.32}{2 \times 9.81}}$;

=0.80s;

Examiners report

27c. *[9 marks]*

Markscheme

(i) upwards;

(ii) y_0 = 0.050(m) and y = 0.030(m);

$\omega = \left(\frac{2\pi}{0.80} = \right) 7.85 \left(\text{rads}^{-1}\right)$;

$v = 7.85\sqrt{[0.05]^2 - [0.03]^2}$;

=0.31ms^{-1} ; (*allow working in cm to give 31 cms^{-1}*);

(iii) λ=4.0m;

recognition that $f = \frac{1}{0.80} (= 1.25)$;
($f\lambda$=)v=1.25×4.0;
(=5.0 ms^{-1})

(iv) y=-3.0 cm, d=0.6 m;

Examiners report

28a. *[3 marks]*

Markscheme

(i) use of $R = \frac{pV}{nT}$; *(award mark if correct substitution seen)*

$\left(\frac{5.2\times10^{-3}\times1.0\times10^{5}}{0.23\times290}\right) = 7.8\text{JK}^{-1}\text{mol}^{-1}$; (accept Pa m^3 mol^{-1} K^{-1})

(ii) the gas is ideal;

Examiners report

(i) Very many candidates were able to arrive at a value for R from the data given. Some however fudged their answer to arrive at the accepted value of 8.31! It was common to see a unit of Pa m3 K-1 mol-1 which, while it is acceptable, shows that the candidate quoting it has little sense of the true meaning of R.

(ii) Most recognized that the gas has to be ideal for the calculation in (i) to be carried through.

28b. *[2 marks]*

Markscheme

constant temperature required; *(do not allow "isothermal")*

a slow compression allows time for (internal) energy to leave gas / *OWTTE*;

Examiners report

Many were able to say that the temperature must not change (isothermal). Too many simply repeated the word "isothermal" from the stem, this gained no credit. However, only a few stated with clarity that the system needs time to allow the energy to leak out *to the surroundings.*

28c. *[4 marks]*

Markscheme

(for adiabatic change) Q=0;
W is positive / work is done by the gas;

$\Delta U = -W$ so ΔU is negative;
(T is a measure of U therefore) T less than 290K***;***

Examiners report

This part was done well, unlike similar questions in recent examinations. Candidates can explain the direction of energy flow and its consequences for the system in terms of the first law of thermodynamics. However, too many failed to use the first law and wrote in general terms about pressure and volume changes.