T8-2 *[166 marks]*

1. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

6. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

7. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

8. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

9a. *[3 marks]*

Markscheme

needs to be windy/high average wind speeds; space/land/room for wind turbines;

ability to import oil/nuclear fuel;

ability to dispose of nuclear waste;

comment relating to need for geological stability;

Examiners report

[N/A]

9b. *[5 marks]*

Markscheme

(i) $\pi 4.7^2$ ***or*** $69.4\ m^2$;

power = 15300 to 15400 W;

470 to 490 GJ;

(ii) wind must retain kinetic energy to escape ***or*** not all KE of wind can be converted to KE of blades;

energy lost to thermal energy (due to friction) in generator/turbine/dynamo;

turbine will suffer downtime when no wind/too much wind;

Allow any two relevant factors.

Examiners report

[N/A]

9c. *[4 marks]*

Markscheme

(i) indication that energy supplied to islanders is output and chemical energy

input /
$\frac{8}{25}$ used;

32% / 0.32;

(ii) energy/it is wasted due to inefficient burning of oil / thermal/heat energy loss to surroundings/environment / electrical energy is used to run the power station's systems / energy/it is wasted due to frictional losses in the turbine/generator;

(iii) heating of wires by electric current / inefficient transformers;

Examiners report

[N/A]

9d. *[3 marks]*

Markscheme

radiation emitted by Earth in (long wavelength) infrared region;

frequency corresponds to resonant frequency of greenhouse gases (either vibration or difference in energy levels);

radiation absorbed by greenhouse gases is (partly) re-radiated back to Earth;

Examiners report

[N/A]

9e. *[2 marks]*

Markscheme

percentage of U-235 in naturally occurring ores is too low to support fission ***or*** naturally occurring U-238 does not undergo fission;

percentage of U-235 (which can usefully capture thermal neutrons) is increased;

Examiners report

[N/A]

9f. *[3 marks]*

Markscheme

$\left({}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3{}^{1}_{0}\mathrm{n}\right)$

235;
36;
3;
The number of neutrons must be consistent with chosen isotope of uranium.

Examiners report

[N/A]

9g. *[3 marks]*

Markscheme

control rods absorb neutrons;
moderators slow down neutrons;
both affect the rate of reaction;
both rely on the neutrons colliding with their atoms/nuclei;
Must see reference to collision/interaction for fourth marking point.

Examiners report

[N/A]

10a. *[3 marks]*

Markscheme

needs to be windy/high average wind speeds; space/land/room for wind turbines;

ability to import oil/nuclear fuel;

ability to dispose of nuclear waste;

comment relating to need for geological stability;

Examiners report

[N/A]

10b. *[5 marks]*

Markscheme

(i) $\pi 4.7^2$ ***or*** $69.4\ m^2$;
power = 15300 to 15400 W; 470 to 490 GJ;

(ii) wind must retain kinetic energy to escape ***or*** not all KE of wind can be converted to KE of blades;
energy lost to thermal energy (due to friction) in generator/turbine/dynamo;
turbine will suffer downtime when no wind/too much wind;
Allow any two relevant factors.

Examiners report

[N/A]

11a. *[8 marks]*

Markscheme

(i) total wind power required $= \frac{750000}{0.3}$;

maximum wind power required per turbine, $P = \frac{750000}{5 \times 0.3} (= 500\text{kW})$;

$d = \left(\frac{8P}{\rho \pi v^3} = \right)^{\frac{1}{2}} 40(\text{m})$

*Award **[1 max]** for an answer of 48.9 (m) as it indicates 5 and 0.3 ignored.*
*Award **[2 max]** for 22 (m) as it indicates 0.3 ignored.*
*Award **[2 max]** for 89 (m) as it indicates 5 ignored.*

(ii) not all kinetic energy can be extracted from wind / losses in cables to community / turbine rotation may be cut off/"feathered" at high or low wind speeds;
Do not allow "wind speed varies" as question gives the average speed.

(iii) less kinetic energy available / wind speed less for turbines behind; turbulence/wake effect; *(do not allow "turbines stacked too close")*

(iv) *implications:* average wind speeds are greater / more space available;
limitations: installation/maintenance cost / difficulty of access / wave damage;
*Must see one each for **[2]**.*

Examiners report

[N/A]

11b. *[7 marks]*

Markscheme

(i) mass of coal per second (=0.0214 kg);
77.1 (kg);
or
energy saved per hour=0.75×3600 (=2700MJh^{-1}) ;

mass of coal saved $= \left(\frac{2700}{35} = \right) 77.1(\text{kg})$;

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

(ii) *advantage:*
energy is free (apart from maintenance and start-up costs) / energy is renewable / sufficient for small community with predominance of wind / supplies energy to remote community / independent of national grid / any other reasonable advantage;
Answer must focus on wind farm not coal disadvantages.

disadvantage:
wind energy is variable/unpredictable / noise pollution / killing birds/bats / large open areas required / visual pollution / ecological issues / need to provide new infrastructure;

(iii) greenhouse gas molecules are excited by/absorbed by/resonate as a result of infrared radiations; { (must refer to infrared
not "heat")
this radiation is re-emitted in all directions;
less greenhouse gas means less infrared/heat returned to Earth; { (consideration of return direction is essential for mark)
temperature falls (to reach new equilibrium);

Examiners report

[N/A]

11c. *[1 mark]*

Markscheme

energy released when a nucleus forms from constituent nucleons / (minimum) energy needed/work done to break a nucleus up into its constituent nucleons;
*Award **[0]** for energy to assemble nucleus.*
Do not allow "particles" or "components" for "nucleons".
Do not accept "energy that binds nucleons together" OWTTE.

Examiners report

[N/A]

11d. *[5 marks]*

Markscheme

*(*i) generally correct shape with maximum shown, trending down to U-235;
maximum shown somewhere between 40 and 70;
*Award **[0]** for straight line with positive gradient from origin.*
*Award **[1]** if maximum position correct but graph begins to rise or flatlines beyond or around U-235.*

(ii) identifies fission as occurring at high nucleon number / at right-hand side of graph;
fission means that large nucleus splits into two (or more) smaller nuclei/nuclei to left of fissioning nucleus (on graph);
(graph shows that) fission products have higher (average) binding energy per nucleon than U-235;
energy released related to difference between initial and final binding energy;
*Award **[2 max]** if no reference to graph.*

Examiners report

[N/A]

11e. *[4 marks]*

Markscheme

(i) $^{235}_{92}\mathrm{U} \rightarrow {}^{231}_{90}\mathrm{Th} + {}^{4}_{2}\alpha$; *(allow He for α; treat charge indications as neutral)*

(ii) time taken for number of unstable nuclei/(radio)activity to halve;
Accept atom/isotope.
Do not accept mass/molecule/amount/substance.

(iii) three half-lives identified;
45 (mg);
*Award **[2]** for bald correct answer.*

Examiners report

[N/A]

12. *[1 mark]*

Markscheme

D

Examiners report

Non-renewable fuels have been produced in the past and so can be produced again, so C represents a common misconception. The key to understanding what is meant by 'non-renewable' is consideration of the time scale of production and consumption.

13. *[1 mark]*

Markscheme

B

Examiners report

14. *[1 mark]*

Markscheme

D

Examiners report

15. *[1 mark]*

Markscheme

A

Examiners report

The stem clearly states that the average temperature of the planet is constant, so neither B nor D can be correct. A correct understanding of albedo leads to A. The statistics would suggest that many candidates had not read the stem carefully.

16. *[1 mark]*

Markscheme

D

Examiners report

17. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

18. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

19. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

20. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

21. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

22. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

23. *[1 mark]*

Markscheme

D

Examiners report

This was the only question that had a negative discrimination index, which means that the weaker candidates tended to prefer the correct response. As *e* is the emissivity of X and we are asked about the intensity of radiation leaving X, the correct response will be qualified by *e*. This automatically discounts A and C. The temperature of T_2 is clearly relevant as the box is emitting radiation towards X, which X will need to re-radiate. Hence it can only be D.

24. *[1 mark]*

Markscheme

D

Examiners report

Many candidates did not factor in *g*. Without it, though, the units would have been incorrect.

25. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

26. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

27a. *[5 marks]*

Markscheme

(i) $m = \rho\Delta V = \rho A\Delta h$;
$=1.1\times10^{3}\times1.4\times10^{5}\times1.8$;
$(\approx 2.8\times10^{8}\,\text{kg})$

(ii) difference in height of centre of mass of water=
$\frac{1.8}{2}=0.9(\text{m})$
$\Delta E_P \left(= mg\Delta h = 2.8\times10^{8}\times9.8\times0.9\right) = 2.5\times10^{9}\,(\text{J})$
electrical energy $(=0.24\times2.5\times10^{9})=5.9\times10^{8}\,(\text{J})(=590\text{MJ})$;
Allow ECF for ***[2 max]*** *if candidate omits factor of 2 in first marking points. Accept* $g=10\text{ms}^{-2}$ *giving an answer of* 6.0×10^{8} *(J).*

Examiners report

ai) Many candidates provided a simple calculation with no explanation to show why the values were multiplied together. This did not provide sufficient evidence to show how the data provided lead to the given value.

aii) Few candidates realized that the energy produced by a water storage is dependent on half the height between the upper and lower water levels.

27b. *[2 marks]*

Markscheme

(i) friction/turbulence of flowing water / friction in turbine/generator / resistive heating in wires;
Do not allow bald statement of "heating".

(ii) it can no longer be used to do work / not available in useful form;
Do not accept "it is more spread out" or similar.

Examiners report

bi) Many candidates provided a general response such as "friction" without identifying the mechanism that caused the frictional losses.

bii) Few candidates could adequately explain the concept of degraded energy.

28a. *[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.

28b. *[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.

28c. *[2 marks]*

Markscheme

$\left(\frac{\sigma R^2 T^4}{d^2} =\right) \frac{5.7\times10^{-8}\times\left[7.0\times10^{8}\right]^2\times\left[5.8\times10^{3}\right]^4}{\left[1.5\times10^{11}\right]^2}$;
$=1.4\times10^{3}(\text{Wm}^{-2})$;
*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.

28d. *[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.

28e. *[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.

28f. *[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.

28g. *[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

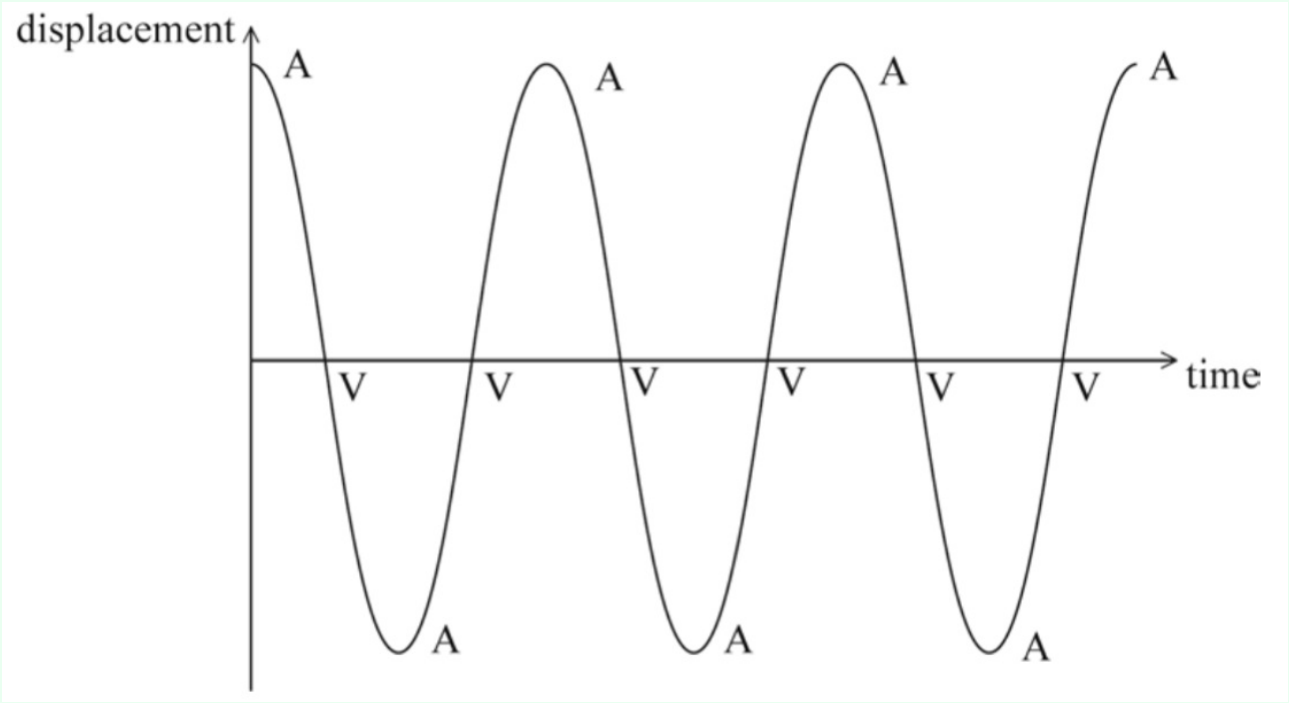
The conditions for simple harmonic motion were poorly outlined by most candidates. Few identified a relationship between force/acceleration and displacement, with most talking about it going backwards and forwards without slowing down.

28h. *[4 marks]*

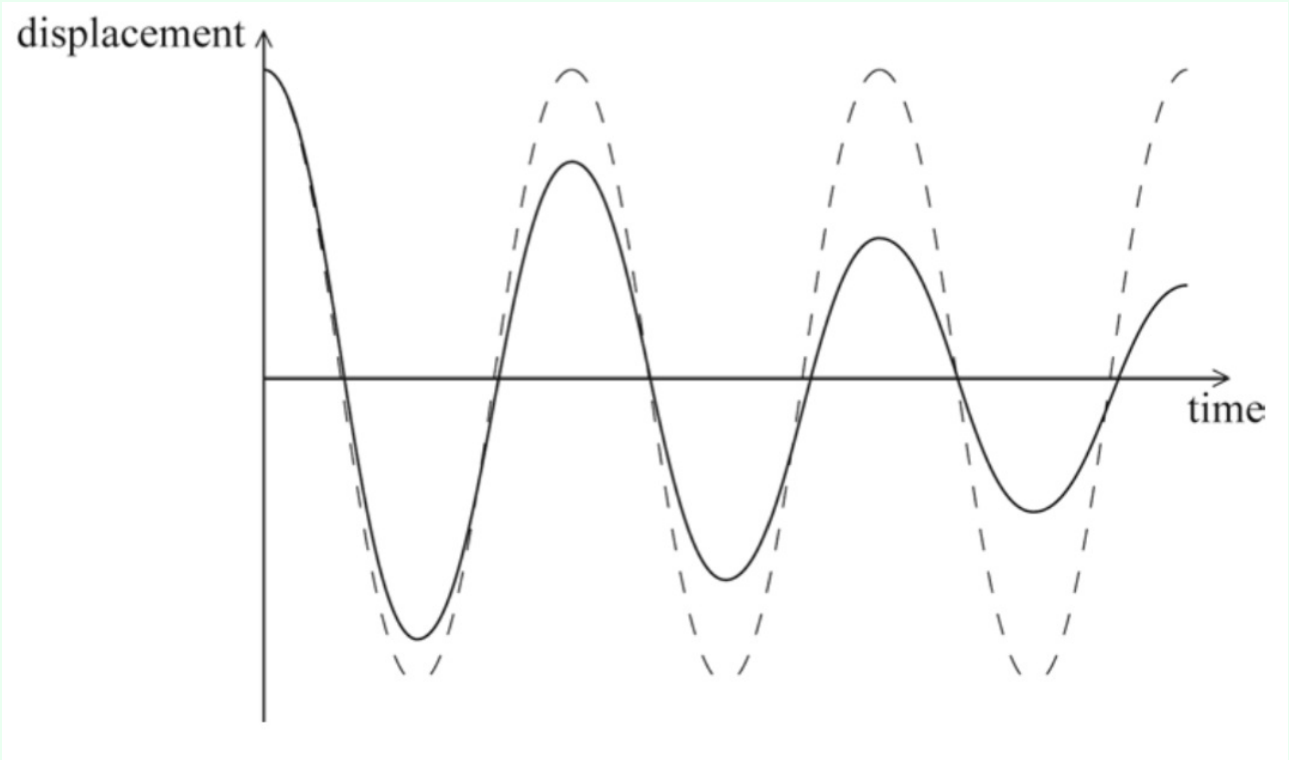
Markscheme

(i) one A correctly shown;

(ii) one V correctly shown;



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



Examiners report

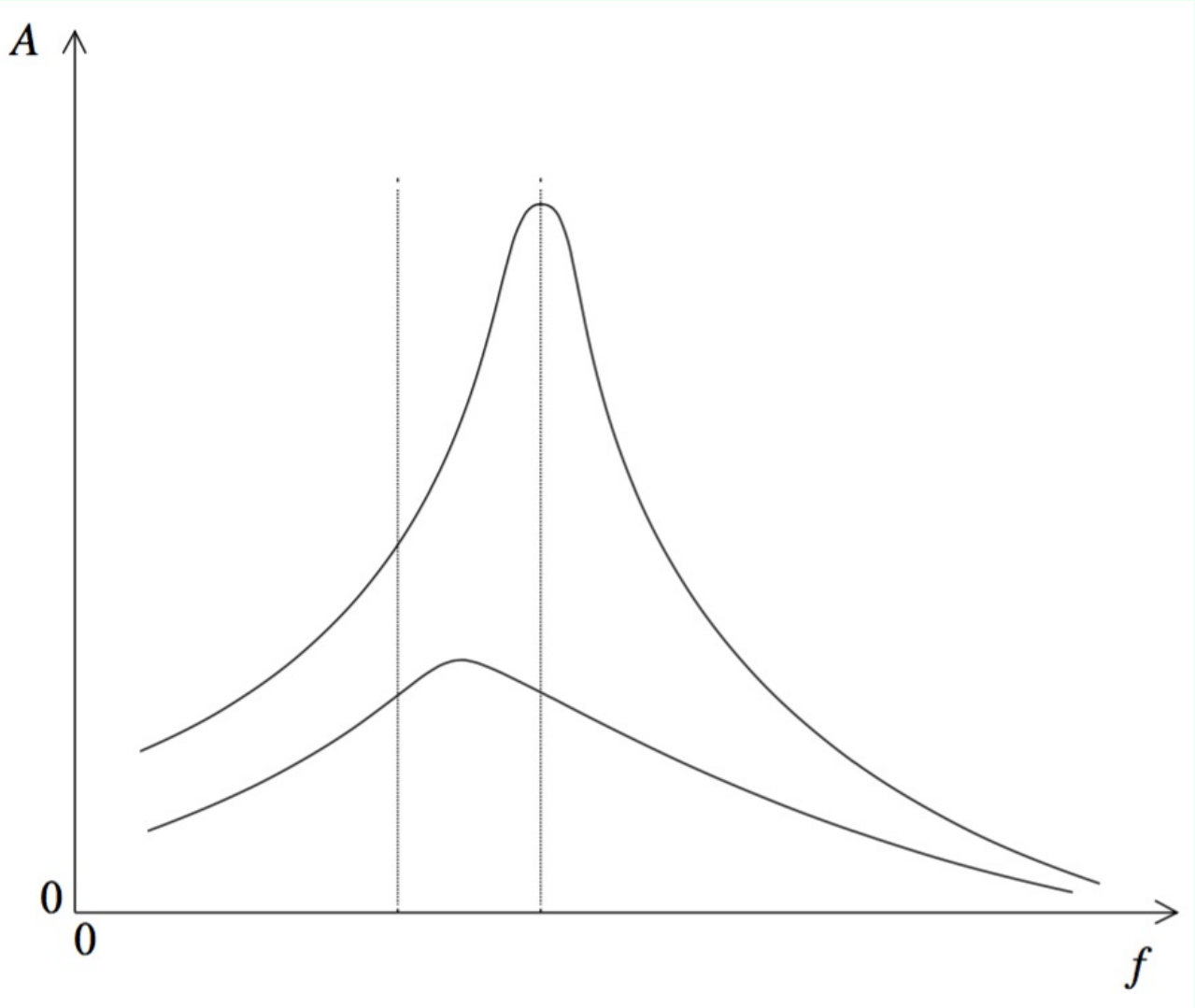
This question was well answered by many. The only notable mistake was with reducing the time period of the damped oscillation.

28i. *[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.

29a. *[2 marks]*

Markscheme

power/energy per second emitted is 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.

29b. *[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.

29c. *[2 marks]*

Markscheme

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

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

*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.

29d. *[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.

29e. *[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.

29f. *[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.

29g. *[4 marks]*

Markscheme

(i) gravitational force / gravitational attraction / weight; *(do not accept gravity)*

(ii) astronauts and spaceship have the same acceleration;
acceleration is towards (centre of) planet;
so no reaction force between astronauts and spaceship;

or

astronauts and spaceships are both falling towards the (centre of the) planet;
at the same rate;
so no reaction force between astronauts and spaceship;

Examiners report

(i) Most were able to state gravitational force, however a significant number stated gravity and consequently did not get the mark.

(ii) Many answers only discussed the astronauts and not the spaceship, missing points such as ‘falling at the same rate’ or ‘with the same acceleration’.

29h. *[2 marks]*

Markscheme

gravitational force equated with centripetal force / $\frac{GmM}{r^2} = \frac{mv^2}{r}$;

$\Rightarrow v^2 = \frac{GM}{r} \Rightarrow \left(v = \sqrt{\frac{GM}{r}}\right)$;

Examiners report

This was well answered with candidates able to adequately show in their explanation where the expression comes from.

29i. *[4 marks]*

Examiners report

ji) Most appreciated that the effect of the force would be to decrease the total energy.

jii) Very few appreciated that they should use the equations above to answer this part of the question. As a consequence, the most common answer discussed a decrease in kinetic energy and a decrease in speed.

30. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

31. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

32. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

33. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

34. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

35. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

36. *[1 mark]*

Markscheme

B

Examiners report

Teachers wished to debate the answer to this question, but the candidates had no problem with it. In paper 1 candidates are required to give the best answer, which here is clearly B.

37. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

38. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

39. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

40. *[2 marks]*

Markscheme

no radioactive waste;
no radiation risks to users;
lower expense of decommissioning / easier to decommission / easier to install / lower set-up cost;
transportation and storage less hazardous/safer;
simpler technology;
cannot be used for military purposes;
fossil fuels can be extracted/found more easily;
no chance of catastrophic accident/meltdown/Chernobyl;

Examiners report

[N/A]

41a. *[1 mark]*

Markscheme

the net (external) force acting on the system is zero / no force acting on system / system is isolated;

Examiners report

[N/A]

41b. *[5 marks]*

Markscheme

(i) no external force/system is isolated so change in momentum is zero; { *(do not accept momentum is conserved/constant)*
force on ball must be equal and opposite to force on the person;
so ball and person/Earth/pond move in opposite directions;

(ii) Newton's second law states that the rate of change of momentum is equal/proportional/directly proportional to the force acting;
the horizontal force acting on the ball is zero therefore the momentum must be constant/the rate of change of momentum is zero;

or

Newton's second law can be expressed as the force acting is equal to the product of mass and acceleration;
the horizontal force acting on the ball is zero therefore the acceleration is zero so velocity is constant (and therefore momentum is constant);

Examiners report

[N/A]

41c. *[2 marks]*

Markscheme

$F = \frac{P}{v}$ ***or*** $\frac{0.75\times10^6}{44}$;
17kN;

Examiners report

[N/A]

41d. *[4 marks]*

Markscheme

(i) $3.7 \times 4.0 = 10 \times v$;
$v = 1.5 \text{ms}^{-1}$;

(ii) KE lost $= \frac{1}{2}\left[3.7 \times 10^3 \times 4.0^2\right] - \frac{1}{2}\left[10 \times 10^3 \times 1.5^2\right]$;
$= 18\text{kJ}$;

Examiners report

[N/A]

41e. *[3 marks]*

Markscheme

initial KE $= \left(\frac{1}{2}\left[10 \times 10^3 \times 1.5^2\right] =\right) 11250\text{J}$;
friction $= \frac{11250}{40}$;
$= 280$ N;

or

use of kinematic equation to give $a = 0.274 \text{ms}^{-1}$;
use of $F(=ma) = 10 \times 10^3 a$;
270/280 N;

Examiners report

[N/A]

41f. *[5 marks]*

Markscheme

(i) methane/CH_4, water vapour/H_2O, carbon dioxide/CO_2, nitrous oxide/N_2O;
*Award **[1]** for any two of the above.*

(ii) *mechanism:*
mention of resonance;
natural frequency of (resonating) greenhouse gas molecules is same as that of infrared radiation from Earth;

or

mention of energy level differences;
differences between energy levels of greenhouse gas molecules matches energy of infrared radiation from Earth;

explanation:
less infrared trapped if absorption is reduced;
so more infrared is transmitted through atmosphere;

or

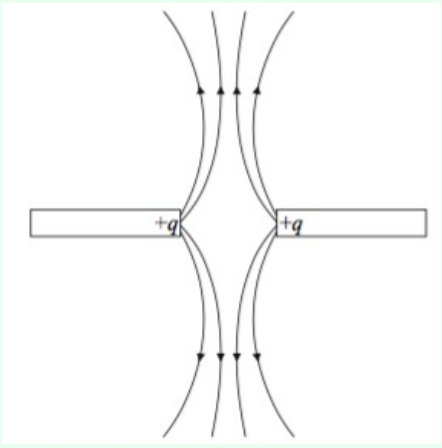
more infrared is trapped if absorption is increased;
so more infrared is re-radiated back to Earth;
Allow only one variant for each alternative.

Examiners report

[N/A]

42. *[2 marks]*

Markscheme



at least four field lines (minimum two per rod) to show overall shape of pattern;
direction of lines all away from poles;

Ignore all working outside region.
Any field lines crossing loses first mark even if accidental.

Examiners report