Energy production *[112 marks]*

1. What is equivalent to $\frac{\text{specific energy of a fuel}}{\text{energy density of a fuel}}$? *[1 mark]*

A. density of the fuel

B. $\frac{1}{\text{density of the fuel}}$

C. $\frac{\text{energy stored in the fuel}}{\text{density of the fuel}}$

D. $\frac{\text{density of the fuel}}{\text{energy stored in the fuel}}$

Markscheme

B

2. Three energy sources for power stations are *[1 mark]*

I. fossil fuel

II. pumped water storage

III. nuclear fuel.

Which energy sources are primary sources?

A. I and II only

B. I and III only

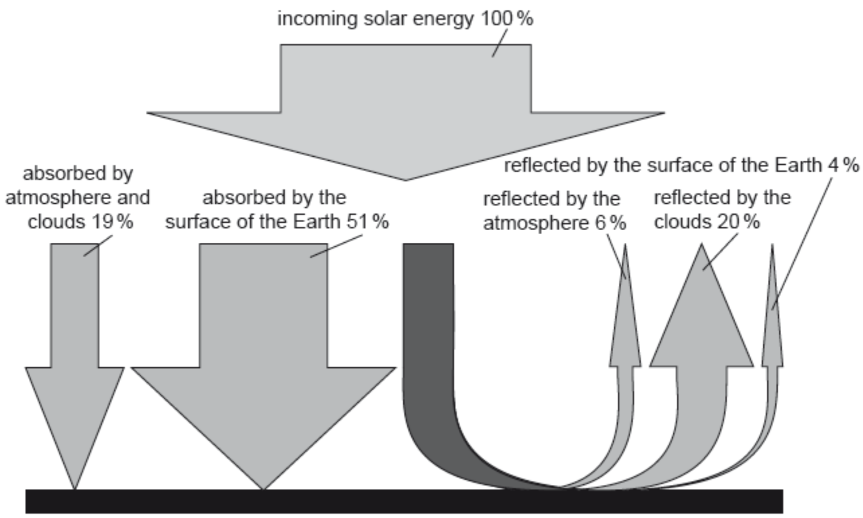
C. II and III only

D. I, II and III

Markscheme

B

3. The diagram shows a simple climate model for the Earth. *[1 mark]*



What does this model predict for the average albedo of the Earth?

A. 0.30

B. 0.51

C. 0.70

D. 0.81

Markscheme

A

---

4. A wind turbine has a power output p when the wind speed is v. The efficiency of the wind turbine does not change. What is the wind speed at which the power output is $\frac{p}{2}$? *[1 mark]*

A. $\frac{v}{4}$

B. $\frac{v}{\sqrt{8}}$

C. $\frac{v}{2}$

D. $\frac{v}{\sqrt[3]{2}}$

Markscheme

D

---

5. Three gases in the atmosphere are *[1 mark]*

I. carbon dioxide (CO_2)

II. dinitrogen monoxide (N_2O)

III. oxygen (O_2).

Which of these are considered to be greenhouse gases?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

A

6. Mars and Earth act as black bodies. The $\frac{\text{power radiated by Mars}}{\text{power radiated by the Earth}} = p$ and $\frac{\text{absolute mean temperature of the surface of Mars}}{\text{absolute mean temperature of the surface of the Earth}} = t$. *[1 mark]*

What is the value of $\frac{\text{radius of Mars}}{\text{radius of the Earth}}$?

A. $\frac{p}{t^4}$

B. $\frac{\sqrt{p}}{t^2}$

C. $\frac{t^4}{p}$

D. $\frac{t^2}{\sqrt{p}}$

Markscheme

B

7. A nuclear reactor contains atoms that are used for moderation and atoms that are used for control. *[1 mark]*

What are the ideal properties of the moderator atoms and the control atoms in terms of neutron absorption?

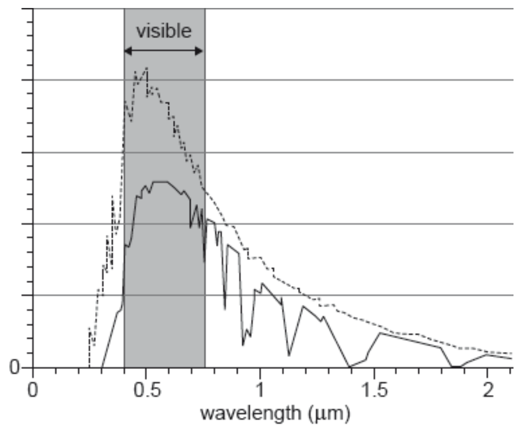
	Ideal moderator atom	Ideal control atom
A.	poor absorber of neutrons	poor absorber of neutrons
B.	poor absorber of neutrons	good absorber of neutrons
C.	good absorber of neutrons	poor absorber of neutrons
D.	good absorber of neutrons	good absorber of neutrons

Markscheme

B

8. The dashed line on the graph shows the variation with wavelength of the intensity of solar radiation before passing through the Earth's atmosphere. *[1 mark]*

The solid line on the graph shows the variation with wavelength of the intensity of solar radiation after it has passed through the Earth's atmosphere.



[Source: Reproduced by permission of Martin Green, UNSW Sydney]

Which feature of the graph helps explain the greenhouse effect?

A. Infrared radiation is absorbed at specific wavelengths.

B. There is little absorption at infrared wavelengths.

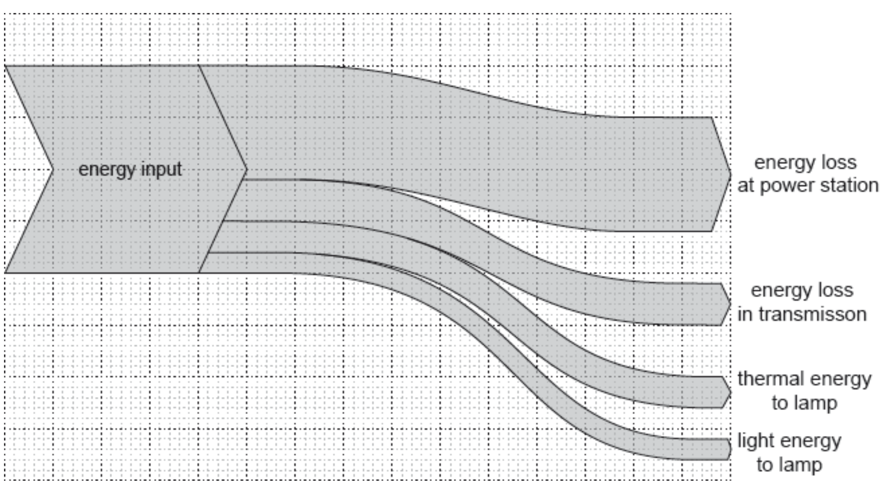
C. There is substantial absorption at visible wavelengths.

D. There is little absorption at UV wavelengths.

Markscheme

A

9. The Sankey diagram shows the energy input from fuel that is eventually converted to useful domestic energy in the form of light in a filament lamp. *[1 mark]*



What is true for this Sankey diagram?

A. The overall efficiency of the process is 10%.

B. Generation and transmission losses account for 55% of the energy input.

C. Useful energy accounts for half of the transmission losses.

D. The energy loss in the power station equals the energy that leaves it.

Markscheme

A

10. What part of a nuclear power station is principally responsible for increasing the chance that a neutron will cause fission? *[1 mark]*

A. Moderator

B. Control rod

C. Pressure vessel

D. Heat exchanger

Markscheme

A

The radioactive nuclide beryllium-10 (Be-10) undergoes beta minus (β–) decay to form a stable boron (B) nuclide.

11a. Identify the missing information for this decay. *[1 mark]*

$${}^{10}_{\square}Be \rightarrow {}^{\square}_{5}B + \beta + \overline{\upsilon}$$

Markscheme

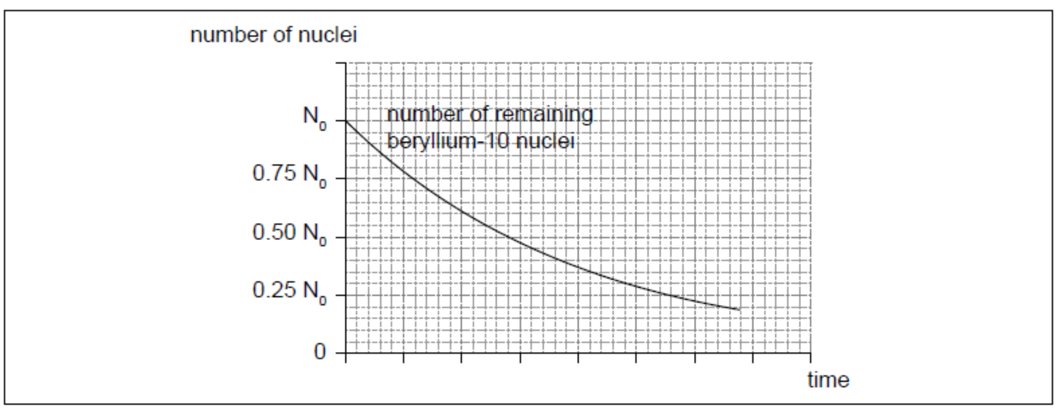
${}^{10}_{4}Be \rightarrow {}^{10}_{5}B + \beta + \overline{V}_e$

conservation of mass number ***AND*** charge ${}^{10}_{5}B$, ${}^{10}_{4}Be$

*Correct identification of both missing values required for **[1]**.*

[1 mark]

The initial number of nuclei in a pure sample of beryllium-10 is N_0. The graph shows how the number of remaining **beryllium** nuclei in the sample varies with time.

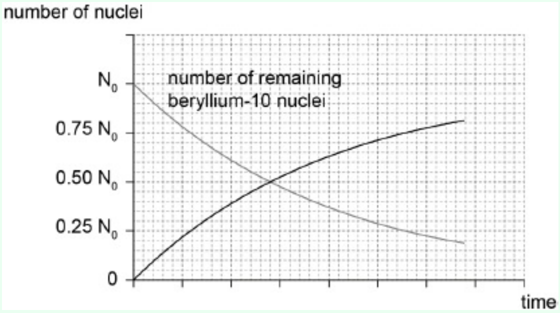


11b. On the graph, sketch how the number of **boron** nuclei in the sample varies with time. *[2 marks]*

Markscheme

correct shape *ie* increasing from 0 to about 0.80 N_0

crosses given line at 0.50 N_0



[2 marks]

11c. After 4.3 × 10^6 years, *[3 marks]*

$$\frac{\text{number of produced boron nuclei}}{\text{number of remaining beryllium nuclei}} = 7.$$

Show that the half-life of beryllium-10 is 1.4 × 10^6 years.

Markscheme

ALTERNATIVE 1

fraction of Be = $\frac{1}{8}$, 12.5%, or 0.125

therefore 3 half lives have elapsed

$t_{\frac{1}{2}} = \frac{4.3 \times 10^6}{3} = 1.43 \times 10^6$ «≈ 1.4 × 10^6» «y»

ALTERNATIVE 2

fraction of Be = $\frac{1}{8}$, 12.5%, or 0.125

$\frac{1}{8} = \mathrm{e}^{-\lambda}(4.3 \times 10^6)$ leading to λ = 4.836 × 10^{-7} «y»$^{-1}$

$\frac{\ln 2}{\lambda}$ = 1.43 × 10^6 «y»

Must see at least one extra sig fig in final answer.

[3 marks]

11d. Beryllium-10 is used to investigate ice samples from Antarctica. A sample of ice initially contains 7.6 × 10^{11} atoms of beryllium-10. State the number of remaining beryllium-10 nuclei in the sample after 2.8 × 10^6 years. *[1 mark]*

Markscheme

1.9 × 10^{11}

[1 mark]

An ice sample is moved to a laboratory for analysis. The temperature of the sample is –20 °C.

11e. State what is meant by thermal radiation. *[1 mark]*

Markscheme

emission of (infrared) electromagnetic/infrared energy/waves/radiation.

[1 mark]

11f. Discuss how the frequency of the radiation emitted by a black body can be used to estimate the temperature of the body. *[2 marks]*

Markscheme

the (peak) wavelength of emitted em waves depends on temperature of emitter/reference to Wein's Law

so frequency/color depends on temperature

[2 marks]

11g. Calculate the peak wavelength in the intensity of the radiation emitted by the ice sample. *[2 marks]*

Markscheme

$\lambda = \frac{2.90 \times 10^{-3}}{253}$

= 1.1×10^{-5} «m»

Allow ECF from MP1 (incorrect temperature).

[2 marks]

11h. Derive the units of intensity in terms of fundamental SI units. *[2 marks]*

Markscheme

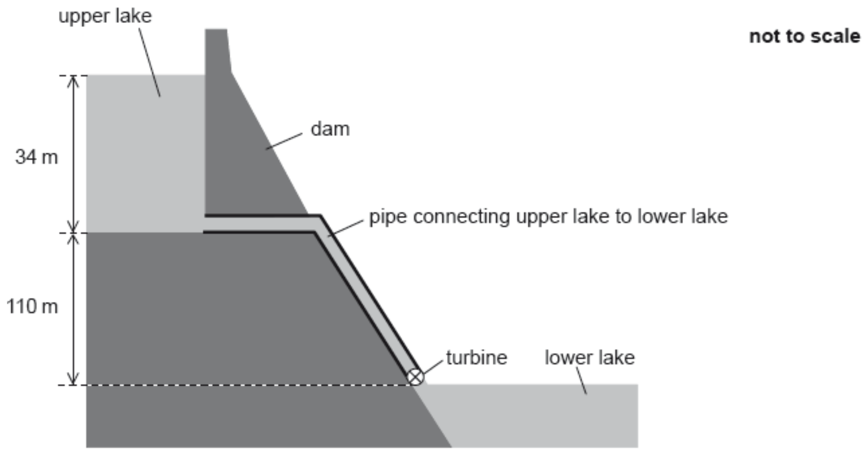
correct units for Intensity (allow *W, Nms^{-1} OR Js^{-1} in numerator)*

rearrangement into proper SI units = kgs^{-3}

Allow ECF for MP2 if final answer is in fundamental units.

[2 marks]

In a pumped storage hydroelectric system, water is stored in a dam of depth 34 m.



The water leaving the upper lake descends a vertical distance of 110 m and turns the turbine of a generator before exiting into the lower lake.

Water flows out of the upper lake at a rate of 1.2×10^5 m^3 per minute. The density of water is 1.0×10^3 kg m^{-3}.

12a. Estimate the specific energy of water in this storage system, giving an appropriate unit for your answer. *[2 marks]*

Markscheme

Average height = 127 «m»

Specific energy «$= \frac{mg\bar{h}}{m} = g\bar{h}$ = 9.81 × 127» = 1.2×10^3 J kg^{-1}

Unit is essential

Allow g = 10 gives 1.3×10^3 J kg^{-1}

Allow ECF from 110 m

(1.1×10^3 J kg^{-1}) or 144 m

(1.4×10^3 J kg^{-1})

[2 marks]

12b. Show that the average rate at which the gravitational potential energy of the water decreases is 2.5 GW. *[3 marks]*

Markscheme

mass per second leaving dam is $\frac{1.2 \times 10^5}{60}$ × 10^3 = «2.0×10^6 kg s^{-1}»

rate of decrease of GPE is = 2.0×10^6 × 9.81 × 127

= 2.49×10^9 «*W*» /2.49 «*GW*»

Do not award ECF for the use of 110 m or 144 m

Allow 2.4 GW if rounded value used from (a)(i) or 2.6 GW if g = 10 is used

[3 marks]

12c. The storage system produces 1.8 GW of electrical power. Determine the overall efficiency of the storage system. *[1 mark]*

Markscheme

efficiency is « $\frac{1.8}{2.5}$ =» 0.72 / 72%

[1 mark]

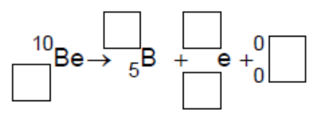
12d. After the upper lake is emptied it must be refilled with water from the lower lake and this requires energy. Suggest how the operators of this storage system can still make a profit. *[1 mark]*

Markscheme

water is pumped back up at times when the demand for/price of electricity is low

[1 mark]

13a. Identify the missing information for this decay. *[2 marks]*



Markscheme

$^{10}_{4}\text{Be} \rightarrow ^{10}_{5}\text{B} + ^{0}_{-1}\text{e} + \overline{\text{V}}_{\text{e}}$

antineutrino ***AND*** charge ***AND*** mass number of electron $^{0}_{-1}\text{e}, \overline{\text{V}}$

conservation of mass number ***AND*** charge $^{10}_{5}\text{B}, ^{10}_{4}\text{Be}$

Do not accept V.

Accept $\overline{V}$ without subscript e.

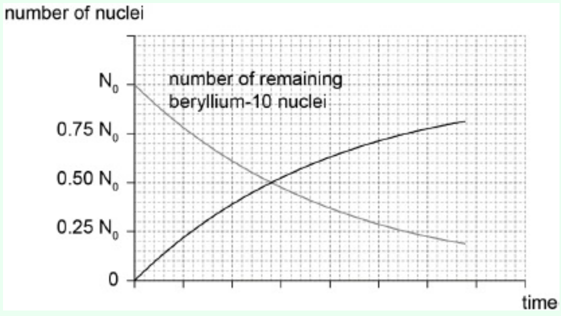
[2 marks]

13b. On the graph, sketch how the number of **boron** nuclei in the sample varies with time. *[2 marks]*

Markscheme

correct shape *ie* increasing from 0 to about 0.80 N_0

crosses given line at 0.50 N_0



[2 marks]

13c. After 4.3 × 10^6 years, [3 marks]

$$\frac{\text{number of produced boron nuclei}}{\text{number of remaining beryllium nuclei}} = 7.$$

Show that the half-life of beryllium-10 is 1.4 × 10^6 years.

Markscheme

ALTERNATIVE 1

fraction of Be = $\frac{1}{8}$, 12.5%, or 0.125

therefore 3 half lives have elapsed

$t_{\frac{1}{2}} = \frac{4.3\times10^6}{3} = 1.43\times10^6$ «≈ 1.4 × 10^6» «y»

ALTERNATIVE 2

fraction of Be = $\frac{1}{8}$, 12.5%, or 0.125

$\frac{1}{8} = \mathrm{e}^{-\lambda}(4.3\times10^6)$ leading to λ = 4.836 × 10^{-7} «y»$^{-1}$

$\frac{\ln 2}{\lambda}$ = 1.43 × 10^6 «y»

Must see at least one extra sig fig in final answer.

[3 marks]

13d. Beryllium-10 is used to investigate ice samples from Antarctica. A sample of ice initially contains 7.6 × 10^{11} atoms of beryllium-10. The present activity of the sample is 8.0 × 10^{-3} Bq. [3 marks]

Determine, in years, the age of the sample.

Markscheme

λ «= $\frac{\ln 2}{1.4\times10^6}$» = 4.95 × 10^{-7} «y^{-1}»

rearranging of $A = \lambda N_0 e^{-\lambda t}$ to give $-\lambda t = \ln \frac{8.0\times10^{-3}\times365\times24\times60\times60}{4.95\times10^{-7}\times7.6\times10^{11}}$ «= –0.400»

$t = \frac{-0.400}{-4.95\times10^{-7}} = 8.1\times10^5$ «y»

Allow ECF from MP1

[3 marks]

13e. State what is meant by thermal radiation. [1 mark]

Markscheme

emission of (infrared) electromagnetic/infrared energy/waves/radiation.

[1 mark]

13f. Discuss how the frequency of the radiation emitted by a black body can be used to estimate the temperature of the body. [2 marks]

Markscheme

the (peak) wavelength of emitted em waves depends on temperature of emitter/reference to Wein's Law

so frequency/color depends on temperature

[2 marks]

13g. Calculate the peak wavelength in the intensity of the radiation emitted by the ice sample. *[2 marks]*

Markscheme

$\lambda = \frac{2.90 \times 10^{-3}}{253}$

= 1.1×10^{-5} «m»

Allow ECF from MP1 (incorrect temperature).

[2 marks]

13h. The temperature in the laboratory is higher than the temperature of the ice sample. Describe **one** other energy transfer that occurs between the ice sample and the laboratory. *[2 marks]*

Markscheme

from the laboratory to the sample

conduction – contact between ice and lab surface.

OR

convection – movement of air currents

Must clearly see direction of energy transfer for MP1.

Must see more than just words "conduction" or "convection" for MP2.

[2 marks]

14. Which of the energy sources are classified as renewable and non-renewable? *[1 mark]*

	Renewable	Non-renewable
A.	Sun	wind
B.	natural gas	geothermal
C.	biomass	crude oil
D.	uranium-235	coal

Markscheme

C

15. The energy density of a substance can be calculated by multiplying its specific energy with which quantity? *[1 mark]*

A. mass

B. volume

C. $\frac{\text{mass}}{\text{volume}}$

D. $\frac{\text{volume}}{\text{mass}}$

Markscheme

C

---

16. A black body emits radiation with its greatest intensity at a wavelength of I_{max}. The surface temperature of the black body doubles without any other change occurring. What is the wavelength at which the greatest intensity of radiation is emitted? *[1 mark]*

A. I_{max}

B. $\frac{I_{max}}{2}$

C. $\frac{I_{max}}{4}$

D. $\frac{I_{max}}{16}$

Markscheme

B

17. The three statements give possible reasons why an average value should be used for the solar constant. *[1 mark]*

I. The Sun's output varies during its 11 year cycle.
II. The Earth is in elliptical orbit around the Sun.
III. The plane of the Earth's spin on its axis is tilted to the plane of its orbit about the Sun.

Which are the correct reasons for using an average value for the solar constant?

A. I and II only

B. I and III only

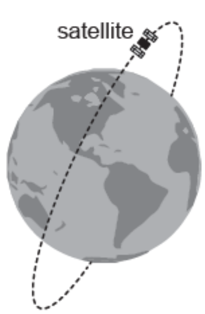
C. II and III only

D. I, II and III

Markscheme

A

A satellite powered by solar cells directed towards the Sun is in a polar orbit about the Earth.



The satellite is orbiting the Earth at a distance of 6600 km from the centre of the Earth.

18a. Determine the orbital period for the satellite. *[3 marks]*

Mass of Earth = 6.0×10^{24} kg

Markscheme

$\frac{mv^2}{r} = G\frac{Mm}{r^2}$

leading to $T^2 = \frac{4\pi^2 r^3}{GM}$

T = 5320 «s»

Alternative 2

«$v = \sqrt{\frac{GM_E}{r}}$» = $\sqrt{\frac{6.67\times10^{-11}\times6.0\times10^{24}}{6600\times10^3}}$ ***or*** 7800 «ms^{-1}»

distance = $2\pi r = 2\pi \times 6600 \times 10^3$ «m» or 4.15×10^7 «m»

«$T = \frac{d}{v} = \frac{4.15\times10^7}{7800}$» = 5300 «s»

Accept use of ω instead of v

The satellite carries an experiment that measures the peak wavelength emitted by different objects. The Sun emits radiation that has a peak wavelength λ_S of 509 nm. The peak wavelength λ_E of the radiation emitted by the Earth is 10.1 µm.

18b. Determine the mean temperature of the Earth. *[2 marks]*

Markscheme

T = «$\frac{2.90\times10^{-3}}{\lambda_{max}} =$» $\frac{2.90\times10^{-3}}{10.1\times10^{-6}}$

= 287 «K» ***or*** 14 «°C»

*Award **[0]** for any use of wavelength from Sun*

Do not accept 287 °C

18c. Suggest how the difference between λ_S and λ_E helps to account for the greenhouse effect. *[3 marks]*

Markscheme

wavelength of radiation from the Sun is shorter than that emitted from Earth «and is not absorbed by the atmosphere»

infrared radiation emitted from Earth is absorbed by greenhouse gases in the atmosphere

this radiation is re-emitted in all directions «including back to Earth»

18d. Not all scientists agree that global warming is caused by the activities of man. *[1 mark]*

Outline how scientists try to ensure agreement on a scientific issue.

Markscheme

peer review

international collaboration

full details of experiments published so that experiments can repeated

[Max 1 Mark]

19\. The following are energy sources. *[1 mark]*

I. a battery of rechargeable electric cells
II. crude oil
III. a pumped storage hydroelectric system

Which of these are secondary energy sources?

A. I and II only

B. I and III only

C. II and III only

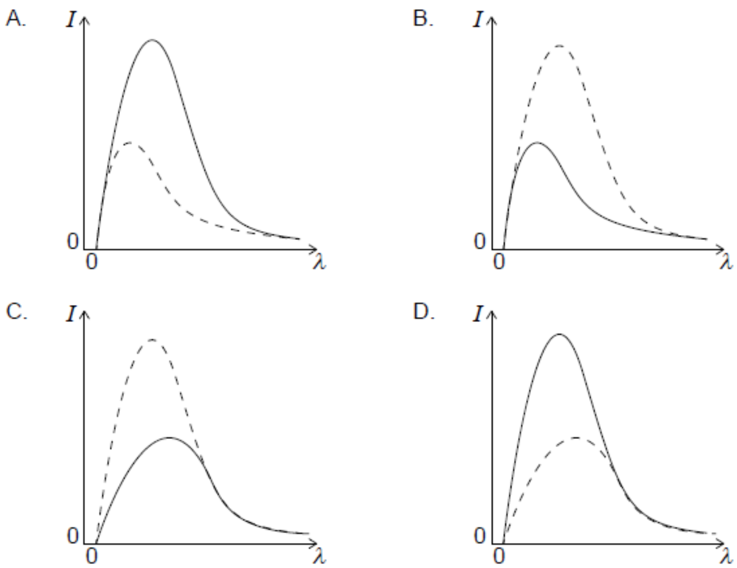
D. I, II and III

Markscheme

B

20\. Planet X and planet Y both emit radiation as black bodies. Planet X has a surface temperature that is less than the surface temperature of planet Y. *[1 mark]*

What is the graph of the variation of intensity *I* with wavelength *λ* for the radiation emitted by planet Y? The graph for planet X is shown dotted.



Markscheme

D

21\. The average surface temperature of Mars is approximately 200 K and the average surface temperature of Earth is approximately 300 K. Mars has a radius half that of Earth. Assume that both Mars and Earth act as black bodies. *[1 mark]*

What is $\frac{\text{power radiated by Mars}}{\text{power radiated by Earth}}$?

A. 20
B. 5
C. 0.2
D. 0.05

Markscheme

D

22. The main role of a moderator in a nuclear fission reactor is to *[1 mark]*

A. slow down neutrons.

B. absorb neutrons.

C. reflect neutrons back to the reactor.

D. accelerate neutrons.

Markscheme

A

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23. A room is at a constant temperature of 300 K. A hotplate in the room is at a temperature of 400 K and loses energy by radiation at a rate of *P*. What is the rate of loss of energy from the hotplate when its temperature is 500 K? *[1 mark]*

A. $\frac{4^4}{5^4}P$

B. $\frac{5^4+3^4}{4^4+3^4}P$

C. $\frac{5^4}{4^4}P$

D. $\frac{5^4-3^4}{4^4-3^4}P$

Markscheme

D

24. An object can lose energy through *[1 mark]*

I. conduction
II. convection
III. radiation

What are the principal means for losing energy for a hot rock resting on the surface of the Moon?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

B

25. The average albedo of glacier ice is 0.25. *[1 mark]*

What is $\frac{\text{power absorbed by glacier ice}}{\text{power reflected by glacier ice}}$?

A. 0.25

B. 0.33

C. 2.5

D. 3.0

Markscheme

D

Two renewable energy sources are solar and wind.

26a. Describe the difference between photovoltaic cells and solar heating panels. *[1 mark]*

Markscheme

solar heating panel converts solar/radiation/photon/light energy into thermal **energy** ***AND*** photovoltaic cell converts solar/radiation/photon/light energy into electrical **energy**

Accept internal energy of water.

26b. A solar farm is made up of photovoltaic cells of area 25 000 m^2. The average solar intensity falling on the farm is 240 W m^{-2} and the average power output of the farm is 1.6 MW. Calculate the efficiency of the photovoltaic cells. *[2 marks]*

Markscheme

power received = 240 × 25000 = «6.0 MW»

efficiency «$= \frac{1.6}{6.0}$» = 0.27 / 27%

An alternative generation method is the use of wind turbines.

The following data are available:

Length of turbine blade = 17 m
Density of air = 1.3 kg m^{-3}
Average wind speed = 7.5 m s^{-1}

26c. Determine the minimum number of turbines needed to generate the same power as the solar farm. *[3 marks]*

Markscheme

area = π × 17^2 «= 908m^2»

power = $\frac{1}{2} \times 908 \times 1.3 \times 7.5^3$ «= 0.249 MW»

number of turbines «$= \frac{1.6}{0.249} = 6.4$» = 7

Only allow integer value for MP3.

*Award **[2 max]** for **25 turbines** (ECF from incorrect power)*

*Award **[2 max]** for **26 turbines** (ECF from incorrect radius)*

26d. Explain **two** reasons why the number of turbines required is likely to be greater than your answer to (c)(i). *[2 marks]*

Markscheme

«efficiency is less than 100% as»

not all KE of air can be converted to KE of blades

OR

air needs to retain KE to escape

thermal energy is lost due to friction in turbine/dynamo/generator

Allow velocity of air after turbine is not zero.

27a. Outline, with reference to energy changes, the operation of a pumped storage hydroelectric system. *[2 marks]*

Markscheme

PE of water is converted to KE of moving water/turbine to electrical energy «in generator/turbine/dynamo»

idea of pumped storage, *ie:* pump water back during night/when energy cheap to buy/when energy not in demand/when there is a surplus of energy

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27b. The hydroelectric system has four 250 MW generators. The specific energy available from the water is 2.7 kJ kg^{-1}. Determine the maximum time for which the hydroelectric system can maintain full output when a mass of 1.5 x 10^{10} kg of water passes through the turbines. *[2 marks]*

Markscheme

total energy = «2.7 x 10^3 x 1.5 x 10^{10} =» 4.05 x 10^{13} «J»

time = «$\frac{4.0\times10^{13}}{4\times2.5\times10^{8}}$» 11.1h ***or*** 4.0 x 10^4 s

*For MP2 the unit **must** be present.*

27c. Not all the stored energy can be retrieved because of energy losses in the system. Explain **one** such loss. *[1 mark]*

Markscheme

friction/resistive losses in walls of pipe/air resistance/turbulence/turbine and generator bearings

thermal energy losses, in electrical resistance of components

water requires kinetic energy to leave system so not all can be transferred

Must see "seat of friction" to award the mark.
Do not allow "friction" bald.

27d. At the location of the hydroelectric system, an average intensity of 180 W m^{-2} arrives at the Earth's surface from the Sun. Solar photovoltaic (PV) cells convert this solar energy with an efficiency of 22 %. The solar cells are to be arranged in a square array. Determine the length of one side of the array that would be required to replace the hydroelectric system. *[2 marks]*

Markscheme

area required $= \frac{1\times10^{9}}{0.22\times180}$ «= 2.5 x 10^7 m^2»

length of one side $= \sqrt{area} = 5.0$ k«m»

28a. Outline the conditions necessary for simple harmonic motion (SHM) to occur. *[2 marks]*

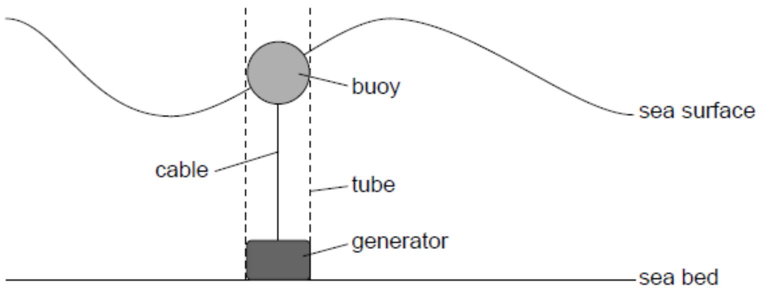
Markscheme

force/acceleration proportional to displacement «from equilibrium position»

and directed towards equilibrium position/point
OR
and directed in opposite direction to the displacement from equilibrium position/point

Do not award marks for stating the defining equation for SHM.
*Award **[1 max]** for a ω–=^{2}x with a and x defined.*

A buoy, floating in a vertical tube, generates energy from the movement of water waves on the surface of the sea. When the buoy moves up, a cable turns a generator on the sea bed producing power. When the buoy moves down, the cable is wound in by a mechanism in the generator and no power is produced.



The motion of the buoy can be assumed to be simple harmonic.

28b. A wave of amplitude 4.3 m and wavelength 35 m, moves with a speed of 3.4 m s $^{-1}$. Calculate the maximum vertical speed of the buoy. *[3 marks]*

Markscheme

frequency of buoy movement $= \frac{3.4}{35}$ ***or*** 0.097 «Hz»

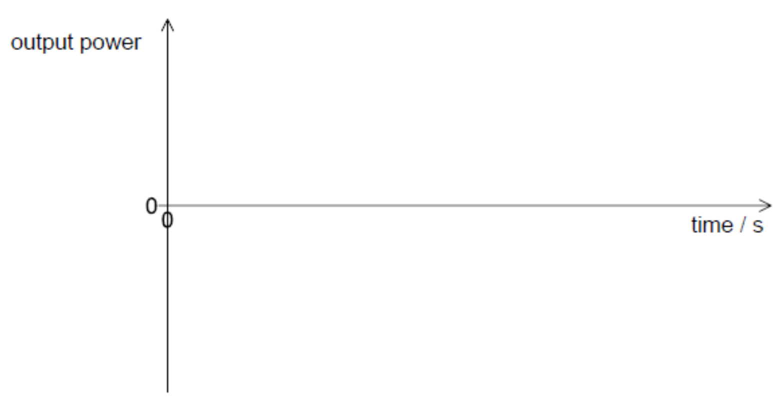
OR

time period of buoy $= \frac{35}{3.4}$ ***or*** 10.3 «s» ***or*** 10 «s»

v = «$\frac{2\pi x_0}{T}$ ***or*** $2\pi f x_0$» $= \frac{2\times\pi\times4.3}{10.3}$ ***or*** $2\times\pi\times0.097\times4.3$

2.6 «m s^{-1}»

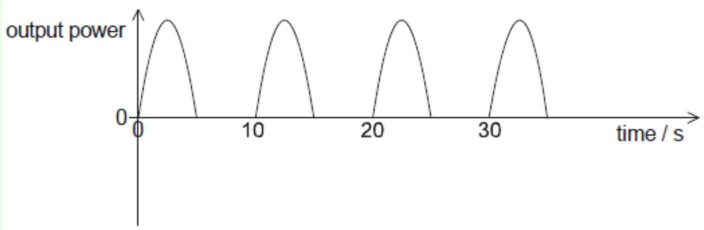
28c. Sketch a graph to show the variation with time of the generator output power. Label the time axis with a suitable scale. *[2 marks]*



Markscheme

peaks separated by gaps equal to width of each pulse «shape of peak roughly as shown»

one cycle taking 10 s shown on graph



Judge by eye.
Do not accept cos_2 or sin_2 graph
At least two peaks needed.
Do not allow square waves or asymmetrical shapes.
Allow ECF from (b)(i) value of period if calculated.

Water can be used in other ways to generate energy.

28d. Outline, with reference to energy changes, the operation of a pumped storage hydroelectric system. *[2 marks]*

Markscheme

PE of water is converted to KE of moving water/turbine to electrical energy «in generator/turbine/dynamo»

idea of pumped storage, *ie:* pump water back during night/when energy cheap to buy/when energy not in demand/when there is a surplus of energy

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28e. The water in a particular pumped storage hydroelectric system falls a vertical distance of 270 m to the turbines. Calculate the speed at which water arrives at the turbines. Assume that there is no energy loss in the system. *[2 marks]*

Markscheme

specific energy available = «gh =» 9.81 x 270 «= 2650J kg^{-1}»

OR

$mgh = \frac{1}{2}mv^2$

OR

$v^2 = 2gh$

v = 73 «ms^{-1}»

Do not allow 72 as round from 72.8

28f. The hydroelectric system has four 250 MW generators. Determine the maximum time for which the hydroelectric system can maintain full output when a mass of 1.5 x 10^{10} kg of water passes through the turbines. *[2 marks]*

Markscheme

total energy = «*mgh* = 1.5 x 10^{10} x 9.81 x 270=» 4.0 x 10^{13} «J»

OR

total energy = «$\frac{1}{2}mv^2 = \frac{1}{2} \times 1.5 \times 10^{10} \times$ (answer (c)(ii))^2 =» 4.0 x 10^{13} «J»

time = «$\frac{4.0 \times 10^{13}}{4 \times 2.5 \times 10^{8}}$» 11.1h ***or*** 4.0 x 10^4 s

Use of 3.97 x 10^{13} «J» gives 11 h.

*For MP2 the unit **must** be present.*

28g. Not all the stored energy can be retrieved because of energy losses in the system. Explain **two** such losses. *[2 marks]*

1. . . . .
. . . .
. . . .

2. . . . .
. . . .
. . . .

Markscheme

friction/resistive losses in pipe/fluid resistance/turbulence/turbine or generator «bearings»
OR
sound energy losses from turbine/water in pipe

thermal energy/heat losses in wires/components

water requires kinetic energy to leave system so not all can be transferred

Must see "seat of friction" to award the mark.

Do not allow "friction" bald.

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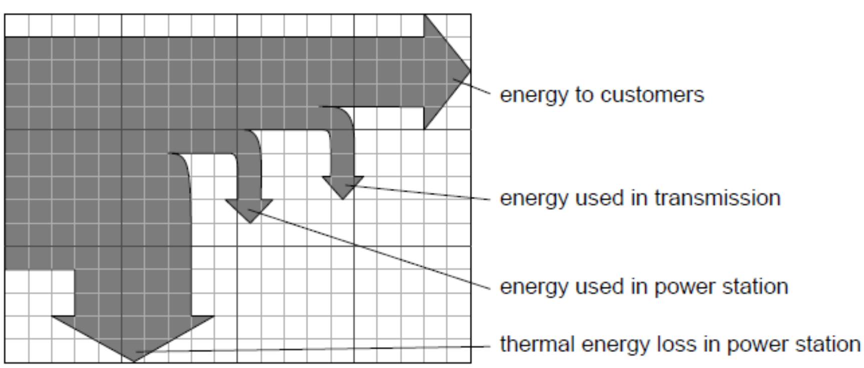
29. The Sankey diagram represents the energy flow for a coal-fired power station. *[1 mark]*



What is the overall efficiency of the power station?

A. 0.3

B. 0.4

C. 0.6

D. 0.7

Markscheme

A

30. Which of the following is **not** a primary energy source? *[1 mark]*

A. Wind turbine

B. Jet Engine

C. Coal-fired power station

D. Nuclear power station

Markscheme

B

31. What are the principal energy changes in a photovoltaic cell and in a solar heating panel? *[1 mark]*

	Photovoltaic cell	Solar heating panel
A.	solar to electrical	solar to thermal
B.	solar to thermal	solar to thermal
C.	solar to electrical	electrical to thermal
D.	solar to thermal	electrical to thermal

Markscheme

A

32. The solar constant is the intensity of the Sun's radiation at *[1 mark]*

A. the surface of the Earth.
B. the mean distance from the Sun of the Earth's orbit around the Sun.
C. the surface of the Sun.
D. 10km above the surface of the Earth.

Markscheme

B

33. X and Y are two spherical black-body radiators that emit the same total power. The absolute temperature of X is half that of Y. *[1 mark]*

What is $\frac{\text{radius of X}}{\text{radius of Y}}$?

A. 4

B. 8

C. 16

D. 32

Markscheme

A

The following data are available for a natural gas power station that has a high efficiency.

Rate of consumption of natural gas	= 14.6 kg s^{-1}
Specific energy of natural gas	= 55.5 MJ kg^{-1}
Efficiency of electrical power generation	= 59.0 %
Mass of CO_2 generated per kg of natural gas	= 2.75 kg
One year	= 3.16×10^7 s

34a. Calculate, with a suitable unit, the electrical power output of the power station. *[1 mark]*

Markscheme

«55.5 × 14.6 × 0.59» = 4.78 × 108 W

A unit is required for this mark. Allow use of J s^{-1}.

No sf penalty.

34b. Calculate the mass of CO_2 generated in a year assuming the power station operates continuously. *[1 mark]*

Markscheme

«$14.6 \times 2.75 \times 3.16 \times 10^7$ =» 1.27×10^9 «kg»

If no unit assume kg

34c. Explain, using your answer to (b), why countries are being asked to decrease their dependence on fossil fuels. *[2 marks]*

Markscheme

CO_2 linked to greenhouse gas OR greenhouse effect

leading to «enhanced» global warming
OR
climate change
OR
other reasonable climatic effect

34d. Describe, in terms of energy transfers, how thermal energy of the burning gas becomes electrical energy. *[2 marks]*

Markscheme

Internal energy of steam/particles OR KE of steam/particles

«transfers to» KE of turbine

«transfers to» KE of generator ***or*** dynamo «producing electrical energy»

Do not award mark for first and last energies as they are given in the question.

Do not allow “gas” for “steam”

Do not accept reference to moving OR turning generator

35. A solar panel has surface area $0.40 m^2$ and efficiency 50%. The average intensity of radiation reaching the surface of the panel is $0.25 kW m^{-2}$. What is the average power output from an array of 10 of these solar panels? *[1 mark]*

A. 0.5 W

B. 5 W

C. 50 W

D. 500 W

Markscheme

D

36. What is the correct order of energy transformations in a coal power station? *[1 mark]*

A. thermal → chemical → kinetic → electrical

B. chemical → thermal → kinetic → electrical

C. chemical → kinetic → thermal → electrical

D. kinetic → chemical → electrical → thermal

Markscheme

B

37. A black body of surface $1.0 m^2$ emits electromagnetic radiation of peak wavelength $2.90 \times 10^{-6} m$. Which of the following statements about the body are correct? *[1 mark]*

I. The temperature of the body is 1000 K.
II. The energy radiated by the body in one second is 5.7×10^4 J.
III. The body is a perfect absorber of electromagnetic radiation.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

D