T8-1 *[166 marks]*

1. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

3a. *[7 marks]*

Markscheme

(i) mention of blades/propeller and turbine/generator/dynamo;

kinetic energy of wind → kinetic energy of turbine;

(rotational) kinetic energy → electricity/electrical energy;

*Award **[1 max]** for statement of (unqualified) kinetic energy to electrical energy*

(ii) $A(=\pi r^2)=6.4\times10^3(m^2)$;
$(P=)1.95$ MW;

(iii) 0.24×1.95MW (=0.47 MW/0.48 MW);
(0.47 MW = 470 kW thus) two generators would meet the maximum demand;
Allow only two generators for the second mark. Do not accept fractional generators.

Examiners report

(i) Many did not mention the kinetic energy of the wind (often referring to 'wind energy'). All types of kinetic energy were referred to as 'mechanical' energy by many candidates. The general structure of this type of wind generator was generally well-known.

(ii) This part was generally well answered with those candidates completing the area calculation usually going on to gain both marks.

(iii) Again, this was well answered with nearly all candidates recognising that is not possible to have fractional generators and, therefore, rounding up their answers to 2 from the 1.7 calculation.

3b. *[2 marks]*

Markscheme

photovoltaic cells generate emf/electricity;
solar panels generate thermal energy/heat / *OWTTE*;

Examiners report

Most candidates knew the difference between photovoltaic cells and solar heating panels. A minority believed that both would normally produce electricity.

3c. *[8 marks]*

Markscheme

(i) emf=3.0 (V);

(ii) series combination of resistance=7.2(Ω);
use of parallel resistance formula;
2.4(Ω);
*Award **[3]** for a bald correct answer*

(iii) attempted use of IV, I^2R or $\frac{V^2}{R}$;
0.94 (W);
Allow ECF from (d)(i) and (d)(ii).
Must see values substituted to gain first mark as compensation.

(iv) (series) increases the total emf/voltage;
(parallel) increases the current/decreases internal resistance/ensures some power if single cell fails / *OWTTE*;

Examiners report

(i) This was not well known and many candidates simply added the emfs to give a value of 9.0 V rather than the correct 3.0 V.

(ii) Nearly all candidates correctly calculated the resistance of the series portions of the modules but there were frequent errors in combining these to find the total resistance – with the parallel formula often being incorrectly written in shorthand

(iii) Although many candidates recognised how they should use the power formula, very few were able to used the correct resistance and the correct voltage.

(iv) Many candidates knew that a failing cell would still allow current in other parallel branches, but few explained that the series combination increased the emf and the parallel combination increased the current in a module.

3d. *[5 marks]*

Markscheme

(i) the solar radiation is captured by a disc of area πR^2 where R is the radius of the Earth;
but is distributed (when averaged) over the entire Earth's surface which has an area four times as large;

or

rays make an angle θ with area of Earth's half-sphere and so average intensity is proportional to average of $\cos^2\theta$ i.e. $\frac{1}{2}$;
there is an additional factor of $\frac{1}{2}$ due to the other half of the sphere;

(ii) variation of solar emission / Earth's orbit is elliptical/not quite circular;

(iii) input power needed =(5×850(kW)=) 4.25×10^6 (W);
$\frac{4.25\times10^6(\mathrm{W})}{3.5\times10^2(\mathrm{Wm^{-2}})} = 1.2\times10^4\ (\mathrm{m^2})$;
*Award **[2]** for a bald correct answer.*

Examiners report

(i) A significant minority of candidates insisted that the reduction in the Sun's intensity was due to radiation reflected from atmosphere. Few went on to do the calculation to support their answer but there were a small number of very good answers to this part.

(ii) Here again, many mentioned radiation reflected by atmosphere rather than variations in solar emissions or the non-circularity of Earth's orbit.

(iii) This part was generally poorly done. The '24-hour period' confused many candidates and few were able to follow the argument through to a logical conclusion.

4. *[1 mark]*

Markscheme

D

Examiners report

Many candidates clearly did not understand the role of the moderator in a nuclear power station.

5. *[1 mark]*

Markscheme

B

Examiners report

6. *[1 mark]*

Markscheme

A

Examiners report

7. *[1 mark]*

Markscheme

D

Examiners report

Most candidates chose the correct response, B. Many teachers commented that various sources support response D as correct. Both B and D were therefore accepted as correct.

8. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

9. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

10. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

11. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

12a. *[4 marks]*

Markscheme

power output of a turbine=$0.3\times\frac{1}{2}\rho Av^3=0.3\times0.5\times1.2\times3.14\times[42]^2\times[12]^3$(=1723kW);

number of turbines needed $= \frac{4\times10^9}{1.723\times10^6}(=2322)$;

area needed = $2322\times5.0\times10^4$;

$=1.2\times10^8(m^2)$;

*Award **[4]** for a bald correct answer.*

Note: Answers sometimes start with calculating power input from wind which is 5743 kW and incorporate 0.3 at a later stage.

Examiners report

This was another calculation in which candidates are becoming well versed. There are a number of steps and many were able to negotiate them with ease. Failures included omitting the efficiency or getting it the wrong way up in the equation. Although full marks were given for the correct answer candidates would be well advised in such questions, to fully explain each step in their argument so that part-credit can be obtained. A jumble of arithmetic with the wrong answer will score zero.

12b. *[3 marks]*

Markscheme

look for these main points:
the surface of Earth re-radiates the Sun's radiation;
greenhouse gases (in atmosphere) readily absorb infrared;
mention of resonance;
the absorbed radiation is re-emitted (by atmosphere) in all directions;
(some of) which reaches the Earth and further heats the surface;
*Award **[1 max]** for responses along the lines that greenhouse gases trap infrared radiation.*

Examiners report

A sizeable majority talked about the infrared radiation being trapped in the atmosphere. This did not attract full credit as it fails to grasp the nettle of the interaction between the earth's surface and the atmosphere. A generous number of points were available on the scheme but most gained two out of three marks. This question was poorly answered by Spanish-speaking candidates.

12c. *[5 marks]*

Markscheme

(i) total absorbed radiation= total emitted radiation =238(Wm $^{-2}$);

temperature of Earth= $\left[\frac{238}{5.67\times10^{-8}}\right]^{\frac{1}{4}}$ =255(K);

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

(ii) total absorbed radiation at surface=238+[($\varepsilon\delta T^4$)0.78×5.67×10^{-8}×250^4];
=410.8(Wm^{-2});

temperature of surface= $\left[\frac{410.8}{5.67\times10^{-8}}\right]^{\frac{1}{4}}$ =291.7(K);

≈292K

Examiners report

(i) temperature of surface

(ii)This was another "show that" question. Candidates need to display reasoning - more able candidates could satisfy examiners on this point.

13. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

14a. *[2 marks]*

Markscheme

a solar heating panel converts the (radiation) energy of the Sun into thermal/heat energy;
(allow "solar energy" but do not allow "heat")
a photovoltaic cell converts the (radiation) energy of the Sun into electrical energy;

Examiners report

In an easy opener, candidates were asked for the energy changes in solar heating panels and photovoltaic cells. Sometimes the word “energy” did not appear in the answer. It is important for candidates to give a clear statement of the initial and the final energy forms expressed in scientific language.

14b. *[2 marks]*

Markscheme

(i) water heater / any specific use such as swimming pool/bath;
(ii) powering TV/radio/lighting/any low energy electrical appliance;

Examiners report

(i) and (ii) There was a wide variety of correct responses here. However some are clearly confused about the uses of solar heating panels and photovoltaics.

14c. *[3 marks]*

Markscheme

surface area of sphere at 1.5×10^{11}m from Sun $=4\pi\times1.50^2\times10^{22}$;

power per m^2=$\frac{3.90\times10^{26}}{4\times3.14\times1.50^2\times10^{22}} = 1.38\times10^3$;
(presence of the substitution allows inference of first marking point)

power per m^2 at surface = $0.7\times1.38\times10^3$Wm^{-2};
(=966Wm^{-2})

Examiners report

This was done well with many correctly showing the intensity arriving from the Sun and incorporating the effect of albedo appropriately.

14d. *[3 marks]*

Markscheme

Earth appears, to the Sun, like a disc of radius R; *(must be explicit)*
intensity=power incident per unit area; *(must be explicit in words or equation)*

(power incident per unit area)=$\frac{966\pi R^2}{4\pi R^2}$;

(=242Wm^{-2})

Examiners report

This was not so impressive (as (c)) with many inclusions of the factor of 4 with no explanation of its origin. This was not acceptable.

14e. *[2 marks]*

Markscheme

(power absorbed) 242 = (power emitted) σT^4 ;

$T = \left[\frac{242}{5.67\times10^{-8}}\right]^{\frac{1}{4}}$ ***or*** 255.5;

(=256K)

Examiners report

This was straightforward but a clear manipulation of Stefan‟s Law was required, ideally with a calculation with significant figures quoted to better than the quoted answer. Many failed in this respect by giving an initial substitution and nothing else. Examiners needed to see correct handling of the fourth root to award full credit.

15a. *[3 marks]*

Markscheme

intensity of the Sun's radiation at the Earth's orbit $=\frac{P}{4\pi d^2}$;
fraction absorbed by the Earth =(1-∝);
the surface area of the disc (absorbing the radiation) $=\pi r^2$;
Look for statements that correctly describe each term.

Examiners report

[N/A]

15b. *[4 marks]*

Markscheme

(i) correct substitution;
to get T=250 (K);

(ii) greenhouse gases in the atmosphere absorb some of the energy radiated by the Earth;
and radiate some of it back to the surface of the Earth;

Examiners report

[N/A]

16a. *[2 marks]*

Markscheme

kinetic energy of wind transferred to (rotational) kinetic energy of turbine/blades;
kinetic energy changed to electrical energy in generator/dynamo;
Generator/dynamo must be mentioned.

Examiners report

[N/A]

16b. *[5 marks]*

Markscheme

(i) volume of cylinder of air passing through blades per second $=v\pi r^2$;
mass of air incident per second=$\rho v\pi r^2$;
kinetic energy per second= $\frac{1}{2}mv^2$;
leading to $\frac{1}{2}\pi\rho r^2 v^3$
*Award **[3]** for answers that combine one or more steps.*

(ii) the speed of the air/wind cannot drop to zero;
wind turbulence / frictional losses in turbine/any moving part / resistive
heating in wires;

Examiners report

[N/A]

16c. *[3 marks]*

Markscheme

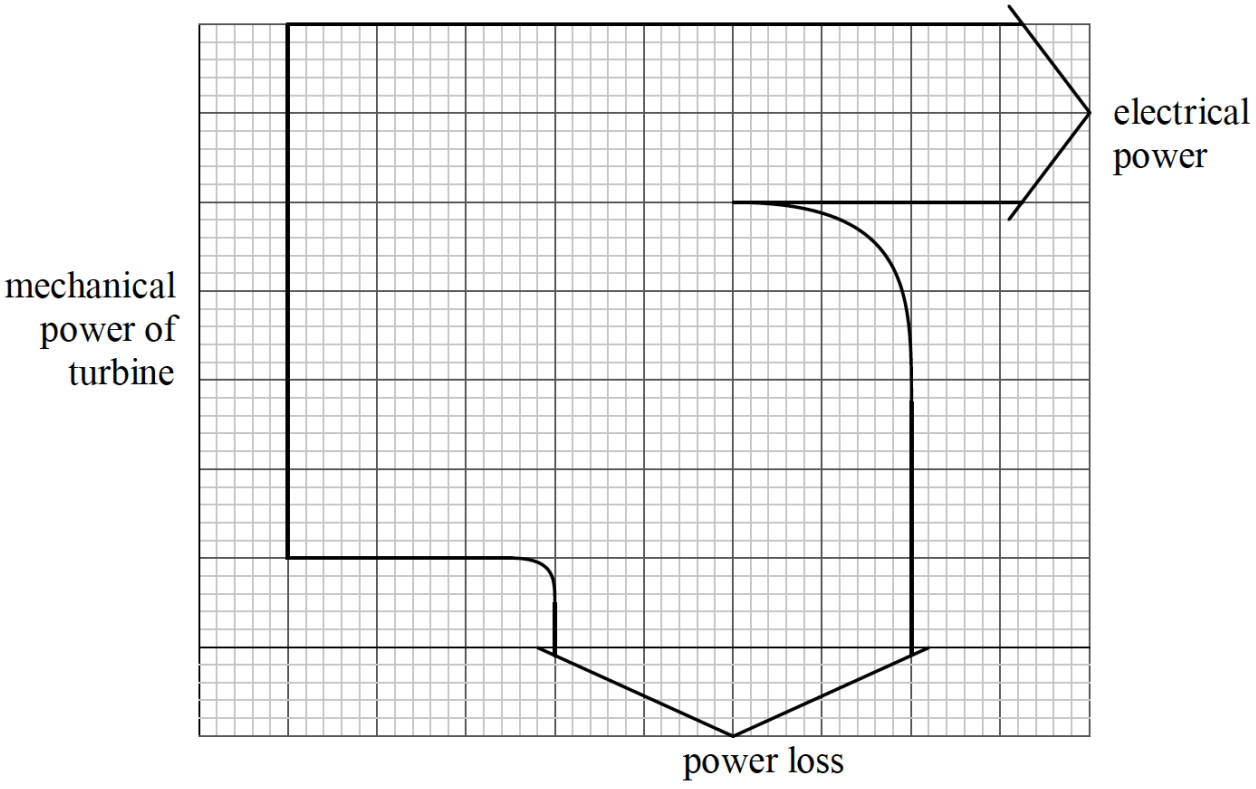
kinetic energy per second of air entering turbine $= \frac{1}{2}\pi \times 1.1 \times 25^2 \times 9.8^3 = 1.016 \times 10^6$;
kinetic energy per second of air leaving turbine $= \frac{1}{2}\pi \times 2.2 \times 25^2 \times 4.6^3 = 2.102 \times 10^5$;
power extracted $= 1.0 \times 10^6 - 2.1 \times 10^5 = 8.062 \times 10^5 \approx 8.1 \times 10^5 \text{W}$;

Examiners report

[N/A]

16d. *[3 marks]*

Markscheme



correct shape of diagram (allow multiple arrows if power loss split into different components);
relative width of arrows correct;
labels correct;

Examiners report

[N/A]

16e. *[2 marks]*

Markscheme

Advantage:
wind is renewable so no resources used up / wind is free / no chemical pollution / no carbon dioxide emission / does not contribute to greenhouse effect / is "scalable" *i.e.* many sizes of turbine possible;

Disadvantage:
expensive initial cost / large land area needed / wind not constant / effect on movement of birds / aesthetically unpleasant / noise pollution / high maintenance costs / best locations far from population centres / low energy density;

Accept any other suitable advantage or disadvantage.

Examiners report

[N/A]

17a. *[8 marks]*

Markscheme

(i) in water, molecules are able to move relative to other molecules, less movement possible in ice / in water, vibration and translation of molecules possible, in ice only vibration;
in liquid there is sufficient energy/vibration (from latent heat) to break and re-form inter-molecular bonds;

(ii) mass of ice=$70000\times35000\times240\times920(=5.4\times10^{14}\text{kg})$;
energy to raise ice temperature to 0°C=$5.4\times10^{14}\times2.1\times10^{3}\times35(=3.98\times10^{19}\text{J})$;
energy to melt ice=$5.4\times10^{14}\times3.3\times10^{5}(=1.8\times10^{20}\text{J})$;
total= $2.2\times10^{20}\text{J}$

(iii) energy incident=$450\times70000\times35000(=1.1\times10^{12}\text{Js}^{-1}\text{m}^{-2})$;
energy available for melting=$1.1\times10^{12}\times0.2(=2.2\times10^{11}\text{J})$;
time $= \left(\frac{2.2\times10^{20}}{2.2\times10^{11}} =\right) 9.9\times10^{8}\text{s}$ ***or*** 32 years;

Examiners report

[N/A]

17b. *[2 marks]*

Markscheme

average albedo of ocean much smaller than (snow and) ice;
so average albedo (of Earth) is reduced;

Examiners report

[N/A]

18a. *[3 marks]*

Markscheme

U-238 is much more common than U-235 in ore;
U-235 is more likely to undergo fission / critical amount of U-235 required to ensure fission / *OWTTE*;
U-238 absorbs neutrons;
U-238 reduces reaction rate in reactor;

Examiners report

[N/A]

18b. *[6 marks]*

Markscheme

(i) $^{137}_{56}\text{Ba}$;
$^{0}_{-1}\beta^{-}$;
anti-neutrino / $\bar{v}$;

(ii) $\lambda = \left(\frac{\ln 2}{30} =\right) 0.0231\text{year}^{-1}$;
$\left(N = N_0\right) \text{e}^{-0.0231\times100}$;
0.099 ***or*** 9.9%;

Examiners report

[N/A]

18c. *[2 marks]*

Markscheme

proportion of waste builds up in fuel rod as uranium is consumed;
increasing numbers of neutrons will be absorbed;
this reduces the number available to sustain the chain reaction;
build up of waste deforms fuel rod (which can then be difficult to remove);

Examiners report

[N/A]

19. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

20. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

21. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

22. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

23. *[1 mark]*

Markscheme

A

Examiners report

Sankey diagrams are quantitative and candidates should understand that the greatest proportion of the output from a fossil-fuelled power station is in the form of thermal energy.

24. *[1 mark]*

Markscheme

D

Examiners report

25. *[1 mark]*

Markscheme

A

Examiners report

The favourite response was the correct one, A. Many teachers, however, pointed out that both A and B could be construed as correct depending upon ones understanding of ‘leads to’ in the stem. Both responses were therefore accepted as correct.

26. *[1 mark]*

Markscheme

A

Examiners report

27. *[1 mark]*

Markscheme

B

Examiners report

28. *[1 mark]*

Markscheme

D

Examiners report

29. *[1 mark]*

Markscheme

B

Examiners report

30a. *[7 marks]*

Markscheme

(i) U-235 fissions / neutrons are produced;

nuclei/neutrons have high energy/are fast moving;
nuclei transfer (kinetic) energy to (reactor) core / neutrons transfer (kinetic) energy to moderator;
names energy of moving nuclei/neutrons as kinetic;
core/moderator energy transferred to coolant/named coolant/surroundings;

(ii) heat exchanger allows transfer of (thermal) energy between reactor and coolant; coolant transfers (thermal) energy to steam/other

named fluid;
steam/fluid allows turbine to drive generator/dynamo;

Examiners report

(i) Outlines of the processes and energy changes in a nuclear power station were very poor. Examiners had to give the benefit of the doubt on many occasions. Some candidates thought that the U-235 is burnt (in the same way as a fossil fuel) to convert the energy for the process. Only rarely were there an attempt to describe the processes consistently and many answers focussed only on the operation of the turbines.
(ii) Equally, the heat exchanger and the turbine roles were poorly described and often simply repeated material from (b)(i).

30b. *[3 marks]*

Markscheme

frequency of vibration is close to that of the frequency of infrared radiation; (atmospheric) carbon dioxide absorbs the infrared radiated by the surface of Earth; the part of the radiation that is re-radiated back to Earth will cause the temperature of the surface to rise / re-radiated at a different frequency / *OWTTE*;

Examiners report

As in part (d) it was rare to find a well-expressed solution and in the case of incorrect evaluations, examiners found it difficult to understand what the candidate was attempting to do.

31. *[5 marks]*

Markscheme

(i) number of fusions required per second $= \frac{2.5\times10^{8}}{2.8\times10^{-12}} \left(= 8.93 \times 10^{19}\right)$;
1 tritium nucleus has mass of 3 amu=$3.0\times1.67\times10^{-27}$(kg)(=$5.0\times10^{-27}$);
total tritium mass required = $4/4.4/4.5/4.48\times10^{-7}$($kgs^{-1}$);
*Award **[3]** for a bald correct answer.*

(ii) *Award any two appropriate problems e.g.*:
difficulty in maintaining high temperature for long periods;
difficulty in maintaining high density of plasma for long periods;
difficulty in enclosing plasma for long periods;
difficulty in controlled removal of heat from plasma;
difficulty in maintaining magnetic fields;

Examiners report

[N/A]

32a. *[3 marks]*

Markscheme

effect caused by gas such as $H_2O/NH_3/CH_4/CO_2$/greenhouse gas in the atmosphere;
gas absorbs outgoing (long wave) radiation from Earth;
gas re-radiates some of the energy back to Earth;

Examiners report

[N/A]

32b. *[9 marks]*

Markscheme

(i) $\frac{3.0\times10^{8}}{6.5\times10^{13}} = 4.6\,(\mu m)$;
≈5(μm)

(ii) water vapour molecules have a natural frequency of oscillation;
if this frequency of oscillation is 6.5×10^{13} / reference to frequency at X;
due to resonance this radiation is readily absorbed by the molecules / the radiation matches the natural frequency of oscillation;

or

X is a natural frequency (of oscillation) of water molecule;
so resonance effects mean that molecules are excited at this frequency;
and energy is removed/less energy transmitted from electromagnetic waves at this (particular) frequency;

(iii) energy gained by absorption needs to be re-emitted (as molecules de-excite);
in other directions / some returns to Earth;

(iv) more greenhouse gases means that there is more absorption of outgoing radiation;
therefore more energy returns to Earth;
leading to a further/greater increase in the temperature of the surface (of Earth);

Examiners report

[N/A]

33. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

34. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

35. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

36. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

37. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

38a. *[4 marks]*

Markscheme

power produced $\left(\frac{24}{0.32}\right)$=75MW;
energy produced in a year (75×10^6×365×24×60×60=)2.37×10^{15}J;
number of reactions required in one year $\left(\frac{2.37\times10^{15}}{3.2\times10^{-11}}\right) = 7.39 \times 10^{25}$;
mass used (7.39×10^{25}×235×1.66×10^{-27})≈29kg;

or

mass used $\left(\frac{7.39\times10^{25}}{6.02\times10^{23}} \times 235 \times 10^{-3}\right) = 29\text{kg}$;

Examiners report

[N/A]

38b. *[3 marks]*

Markscheme

the neutrons would not be slowed down;
therefore they would not be/have less chance of being captured/induce fission;
so (much) less/no power would be produced;

Examiners report

[N/A]

38c. *[3 marks]*

Markscheme

(i) beta decay;

(ii) the reactions end up producing plutonium (from uranium 238);
(this isotope of) plutonium may be used to manufacture nuclear weapons / can be used as fuel in other reactors / plutonium is extremely toxic;

or

the products of the reactions are radioactive for long periods of time / *OWTTE*;
therefore posing storage/safety problems;

Examiners report

[N/A]

39a. *[2 marks]*

Markscheme

the solar radiation is captured by a disc of area πR^2 where R is the radius of the Earth;
but is distributed (when averaged) over the entire Earth's surface which has an area four times as large;
*Award **[1]** for reference to absorption/reflection.*

Examiners report

[N/A]

39b. *[4 marks]*

Markscheme

(i) 0.700;

(ii) $I(= e\sigma T_a^4) = 0.70 \times 5.67 \times 10^{-8} \times 242^4$;
$= 136 \text{Wm}^{-2}$

(iii) $\sigma T_e{}^4 = 136 + 245 \text{Wm}^{-2}$;
hence $T_e \left(= \sqrt[4]{\frac{381}{5.67 \times 10^{-8}}} \right) = 286 \text{K}$;

Examiners report

[N/A]

39c. *[7 marks]*

Markscheme

(i) the Earth radiates radiation in the infrared region of the spectrum; the greenhouse gases have energy level differences (in their molecular energy levels) corresponding to infrared energies;
and so the infrared photons are absorbed;
or
the Earth radiates photons of infrared frequency;
the greenhouse gas molecules oscillate/vibrate with frequencies in the infrared region;
and so because of resonance the photons are absorbed;

(ii) most incoming radiation consists of photons in the visible/ultraviolet region /photons of much shorter wavelength than those radiated by the Earth / photons of different wavelength of that radiated by Earth;
and so these cannot be absorbed;

(iii) *Source:* emissions from volcanoes/burning of fossil fuels in power plants/cars/breathing;
Sink: oceans / rivers / lakes / seas / trees;

Examiners report

[N/A]