MCQ - ENERGY and CLIMATE

1. The volume of a given mass of water at a temperature of \(T_1\) is \(V_1\). The volume increases to \(V_2\) at temperature \(T_2\). The coefficient of volume expansion of water may be calculated from

A. \(\frac{V_2}{T_2} - \frac{V_1}{T_1}\)  
B. \(\frac{V_2 - V_1}{T_2 - T_1}\)  
C. \(\frac{V_2 - V_1}{V_1(T_2 - T_1)}\)  
D. \(\frac{V_2 - V_1}{V_2(T_2 - T_1)}\)

2. The commercial production of energy by nuclear fusion is not yet possible mainly due to difficulties with

A. obtaining plentiful supplies of a suitable fuel.  
B. reaching the high temperatures required.  
C. confining the hot plasma.  
D. disposing of the radioactive waste products.

3. A wind generator produces 5.0 kW of power for a wind speed of 6.0 ms\(^{-1}\). The best estimate for the power produced for a wind speed of 12.0 m s\(^{-1}\) is

A. 10 kW.  
B. 25 kW.  
C. 40 kW.  
D. 125 kW.

4. It is hypothesized that global warming may lead to significant changes in the average sea-level. This hypothesis assumes that

A. average rainfall will increase.  
B. icebergs will melt.  
C. glaciers will melt.  
D. the rate of evaporation of seawater will increase.

5. Two black bodies X and Y are at different temperatures. The temperature of body Y is higher than that of body X. Which of the following shows the black body spectra for the two bodies?

A.  
B.  
C.  
D.  

![Diagram of black body spectra for two bodies X and Y, showing different intensities at various wavelengths.](image-url)
6. The diagram below shows a simplified model of the energy balance for Earth.

The albedo of the Earth according to this model is equal to
A. $\frac{2}{340}$  
B. $\frac{100}{340}$  
C. $\frac{238}{340}$  
D. $\frac{240}{340}$

7. The most efficient energy conversion occurs in
A. tidal power stations  
B. diesel engines  
C. solar panels  
D. hydro-electric power stations

8. The original source of tidal power is the
A. Moon  
B. Earth  
C. Sun  
D. water

9. Heat engines
A. produce more work output than energy input  
B. take in thermal energy at a low temperature and exhaust it at high temperature  
C. convert heat into mechanical energy  
D. can be close to 100% efficient

10. All the following statements are correct EXCEPT
A. generators convert mechanical energy into electrical energy  
B. nuclear reactors convert mass into energy  
C. chemical energy is a form of potential energy  
D. thermal energy and solar energy are the same

11. Two different objects that have different temperatures are in thermal contact with one another. It is the temperatures of the two objects that determines,
A. the amount of internal energy in each object  
B. the process by which thermal energy is transferred  
C. the specific heat capacity of each object  
D. the direction of transfer of thermal energy between the objects
12. A generator takes in an amount $E_k$ of kinetic energy. An amount $W$ of useful electrical energy is produced. An amount $Q$ of thermal energy is lost due to the moving parts of the generator. The law of conservation of energy and the efficiency of the generator are given by which of the following?

<table>
<thead>
<tr>
<th>Law of conservation of energy</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_k = W + Q$</td>
<td>$W / E_k$</td>
</tr>
<tr>
<td>$E_k = W + Q$</td>
<td>$W / Q$</td>
</tr>
<tr>
<td>$E_k = W - Q$</td>
<td>$W / Q$</td>
</tr>
<tr>
<td>$E_k = W - Q$</td>
<td>$W / (E_k - Q)$</td>
</tr>
</tbody>
</table>

13. Which one of the following is not considered to be a fossil fuel?
A. wood
B. uranium
C. coal
D. crude oil

14. The correct rank advance for rank advance of coal is:
A. lignite, peat, bituminous coal, anthracite
B. bituminous coal, peat, anthracite, lignite
C. peat, lignite, bituminous coal anthracite
D. antracite, lignite, bituminous coal, peat

15. The fuel below with the highest energy density value is:
A. coal
B. crude oil
C. ethanol
D. compressed natural gas

16. The term critical mass refers to
A. the mass defect when a fissile nucleus decays.
B. the mass of a fissile nucleus.
C. the mass required for a self-sustaining fission reaction.
D. the mass of uranium-235 required to fuel a nuclear reactor.

17. The purpose of the control rods in a nuclear reactor is to:
A. absorb excess neutrons
B. to slow down the neutrons
C. provide a container for the fuel
D. reduce the radioactivity of the fissile materials

18. Solar energy:
A. is converted completely into electricity in a photovoltaic cell
B. is not able to be stored
C. is a renewable energy source
D. is suitable only for heating water

19. All the following statements are correct EXCEPT
A. generators convert mechanical energy into electrical energy
B. nuclear reactors convert mass into energy
C. chemical energy is a form of potential energy
D. thermal energy and solar energy are the same

20. All of the following are natural greenhouse gases EXCEPT:
A. methane
B. nitrogen
C. water vapour
D. nitrous oxide
21. A perfectly black body sphere is at a steady temperature of 473 K and is enclosed in a container at absolute zero temperature. It radiates thermal energy at a rate of 300 J s\(^{-1}\). If the temperature of the sphere is increased to 946 K it radiates heat at a rate of:

A. 300 W  
B. 1200 W  
C. 3200 W  
D. 4800 W

If the radius of the sphere is doubled it radiates heat at a rate of:

A. 300 W  
B. 1200 W  
C. 3200 W  
D. 4800 W

If the temperature of the enclosure is raised to 500 K it radiates heat at a rate of:

A. 300 W  
B. 1200 W  
C. 3200 W  
D. 4800 W

If the enclosure is at 473 K the net rate of heat loss would be:

A. 0 W  
B. 300 W  
C. 1200 W  
D. 100 000 W

22. The relative intensities of the emitted wavelengths of a perfect black body are dependant on the

A. the surface area of the black body  
B. the temperature of the black body  
C. the radiation per square metre  
D. the radiation per second

23. Which of the following is a fission reaction?

A. \[^{235}_{92}\text{U} \rightarrow ^{4}_{2}\text{He} + ^{231}_{90}\text{Th}\]
B. \[^{12}_{6}\text{C} + ^{1}_{1}\text{H} \rightarrow ^{13}_{7}\text{N} + \gamma\]
C. \[^{4}_{2}\text{He} + ^{14}_{7}\text{N} \rightarrow ^{17}_{8}\text{O} + ^{1}_{1}\text{H}\]
D. \[^{233}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{140}_{58}\text{Ce} + ^{92}_{34}\text{Se} + 2^{1}_{0}\text{n}\]

24. Fission is the process by which

A. two light nuclei combine to form a heavier nucleus.  
B. a heavy nucleus splits to form two lighter nuclei.  
C. a heavy nucleus splits to form an alpha particle and another nucleus.  
D. a light nucleus splits to form an electron and another nucleus.

25. Identify the missing product in the reaction

\[^{239}_{94}\text{Pu} + ^{1}_{0}\text{n} \rightarrow ^{106}_{44}\text{Ru} + \ldots + 2^{1}_{0}\text{n}\]

A. \(^{133}_{50}\text{Sn}\)
B. \(^{134}_{50}\text{Sn}\)
C. \(^{132}_{50}\text{Sn}\)
D. \(^{131}_{50}\text{Sn}\)
26. Doping a semiconductor to improve its conductivity means:
A. adding elements with 3 valence electrons
B. adding silicon or germanium to the semiconductor
C. adding group 3 and group 5 elements
D. adding elements with 5 valence electrons

27. Photovoltaic cells can operate when the incident photons have
A. frequencies above visible light
B. infra-red frequencies
C. microwave frequencies
D. frequencies below visible light

28. The efficiency of a modern natural gas power station is approximately
A. 10 %.
B. 50 %.
C. 75 %.
D. 90 %.

29. The energy source that currently provides the greatest proportion of the world’s total energy demand is
A. coal.
B. oil.
C. natural gas.
D. uranium.

30. In a nuclear power station, uranium is used as the energy source and plutonium-239 is produced. Which of the following is true?
A. Plutonium-239 is produced by nuclear fusion.
B. A moderator is used to absorb plutonium-239.
C. Control rods are used to slow down plutonium-239.
D. Plutonium-239 can be used as a fuel in another type of nuclear reactor.

31. One disadvantage of using photovoltaic cells to power a domestic water heater is that
A. solar energy is a renewable source of energy.
B. the power radiated by the Sun varies significantly depending on the weather.
C. a large area of photovoltaic cells would be needed.
D. photovoltaic cells contain CFCs, which contribute to the greenhouse effect.

32. Greenhouse gases
A. reflect infrared radiation but absorb ultraviolet radiation.
B. reflect ultraviolet radiation but absorb infrared radiation.
C. transmit infrared radiation but absorb ultraviolet radiation.
D. transmit ultraviolet radiation but absorb infrared radiation.

33. The rate of global warming might be reduced by
A. replacing the use of coal and oil with natural gas.
B. a reduction in the Earth’s albedo.
C. a reduction in carbon fixation.
D. an increase in deforestation.

34. The unit of energy density of a fuel is
A. J m$^{-2}$.
B. J m$^{-3}$.
C. J kg$^{-1}$.
D. kg J$^{-1}$. 
35. Which of the following is the best estimate for the overall efficiency of a typical coal power station?

A. 5 %
B. 30 %
C. 60 %
D. 90 %

36. When sunlight is incident on a solar cell an electric current is produced. This is due to

A. a temperature gradient within the cell.
B. very long wavelength infrared radiation.
C. very short ultraviolet radiation.
D. the photoelectric effect.

37. The power per unit length \( P \) of an oscillating water column (OWC) is due to the action of a surface wave of amplitude \( A \). Which of the following correctly relates \( P \) and \( A \), and correctly identifies the nature of the energy of the water column?

<table>
<thead>
<tr>
<th>Relation between ( P ) and ( A )</th>
<th>Nature of energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ( P = A )</td>
<td>kinetic</td>
</tr>
<tr>
<td>B. ( P = A^2 )</td>
<td>kinetic and potential</td>
</tr>
<tr>
<td>C. ( P = A^2 )</td>
<td>kinetic</td>
</tr>
<tr>
<td>D. ( P = A^2 )</td>
<td>kinetic and potential</td>
</tr>
</tbody>
</table>

38. The average temperature of the surface of the Sun is about 20 times more than the average surface temperature of the Earth. The average power per unit area radiated by the Earth is \( P \). The average power per unit area radiated by the Sun is

A. 20 \( P \).
B. 400 \( P \).
C. 8000 \( P \).
D. 160 000 \( P \).

39. Global warming reduces the ice and snow cover on Earth. Which of the following correctly describes the changes in albedo and rate of energy absorption by Earth?

<table>
<thead>
<tr>
<th>Albedo</th>
<th>Rate of energy absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>increase</td>
</tr>
<tr>
<td>B.</td>
<td>decrease</td>
</tr>
<tr>
<td>C.</td>
<td>increase</td>
</tr>
<tr>
<td>D.</td>
<td>decrease</td>
</tr>
</tbody>
</table>

40. A radio-isotope has an activity of 400 Bq and a half-life of 8 days. After 32 days the activity of the sample is

A. 200 Bq.
B. 100 Bq.
C. 50 Bq.
D. 25 Bq.
41. Which of the following energy sources results from the solar energy incident on Earth?

A. Nuclear fission
B. Wind energy
C. Nuclear fusion
D. Geothermal energy

42. Which of the following is a renewable and non-renewable energy source?

A. uranium  coal
B. tidal  uranium
C. uranium  biogas
D. natural  gas biogas

43. A thermal power station is 20% efficient and generates useful electrical power at 1000 MW. The fossil fuel used has an energy density of 50 MJ kg\(^{-1}\). The mass of fuel in kg consumed every second is given by which of the following?

A. 0.01
B. 0.25
C. 4
D. 100

44. Which of the following is likely to increase greenhouse gas concentrations in the atmosphere?

A. Using natural gas instead of coal to generate electrical energy
B. Incineration of waste to generate electrical energy
C. Increased use of wind turbines to generate electrical energy
D. Carbon dioxide capture and storage at the power station

45. Venus and Earth may be regarded as behaving as black bodies. The mean temperature at the surface of Venus is about 600 K and at the surface of Earth is about 300 K. Which of the following is the best estimate for the ratio

\[
\frac{\text{power radiated per unit area on Earth}}{\text{power radiated per unit area on Venus}}
\]

A. \(\frac{1}{2}\)  
B. \(\frac{1}{4}\)  
C. \(\frac{1}{8}\)  
D. \(\frac{1}{16}\)

46. In a nuclear power station, a moderator is required to

A. control the rate of fission.
B. reduce heat losses to the surroundings.
C. reduce the energy of high energy neutrons.
D. increase the energy of low energy neutrons.

47. Degraded energy is energy that is

A. stored in the Earth’s atmosphere.
B. available from non-renewable energy sources.
C. converted into work in a cyclical process.
D. no longer available for the performance of useful work.

48. Which of the following correctly describes both the role of the moderator and of the control rods in a nuclear reactor?

<table>
<thead>
<tr>
<th>Moderator</th>
<th>Control rods</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. slows down the neutrons</td>
<td>maintain a constant rate of fission</td>
</tr>
<tr>
<td>B. cools down the reactor</td>
<td>extract thermal energy</td>
</tr>
<tr>
<td>C. cools down the reactor</td>
<td>maintain a constant rate of fission</td>
</tr>
<tr>
<td>D. slows down the neutrons</td>
<td>extract thermal energy</td>
</tr>
</tbody>
</table>
49. Which of the following correctly shows the energy change in a photovoltaic cell and in a solar heating panel?

<table>
<thead>
<tr>
<th>Photovoltaic cell</th>
<th>Solar heating panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>solar → electrical</td>
<td>solar → thermal</td>
</tr>
<tr>
<td>electrical → thermal</td>
<td>solar → electrical</td>
</tr>
<tr>
<td>solar → electrical</td>
<td>electrical → thermal</td>
</tr>
<tr>
<td>electrical → thermal</td>
<td>solar → thermal</td>
</tr>
</tbody>
</table>

50. The albedo for the oceans is lower than that for glaciers. This is because, compared to ice, sea water

A. has a greater density.
B. has a greater specific heat capacity.
C. has a greater coefficient of volume expansion.
D. absorbs a greater amount of radiative power.

51. Which of the following is most likely to reduce the enhanced greenhouse effect?

A. Replace the use of gas powered stations with oil powered stations
B. Replace coal-fired power stations with nuclear power stations
C. Increase the use of all non-renewable energy sources
D. Decrease the efficiency of power production

52. Which of the following correctly shows a renewable and a non-renewable source of energy?

<table>
<thead>
<tr>
<th>Renewable</th>
<th>Non-renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil</td>
<td>geothermal</td>
</tr>
<tr>
<td>wind</td>
<td>biofuels</td>
</tr>
<tr>
<td>ocean waves</td>
<td>nuclear</td>
</tr>
<tr>
<td>natural gas</td>
<td>coal</td>
</tr>
</tbody>
</table>

53. Critical mass refers to the amount of fissile material that

A. will allow fission to be sustained.
B. is equivalent to 235 g of uranium.
C. will produce a growing chain reaction.
D. is the minimum mass necessary for fission to take place.

54. The annual variations of solar power incident per unit area at a particular point on the Earth’s surface is mainly due to the change in the

A. distance between the Earth and the Sun.
B. angle at which the solar rays hit the surface of the Earth.
C. average albedo of the Earth.
D. average cloud cover of the Earth.
55. The water in a reservoir behind a dam drops from an initial height $H_0$ above a turbine to produce hydroelectricity. At time $t = T$, $h = 0$.

The graph shows the variation with time $t$ of the height $h$ of the water above the turbine.

Which of the following is a measure of the maximum theoretical electric power available?
A. $H_0$ and the slope of the graph
B. $T$ and the slope of the graph
C. $T$ and the area under the graph
D. $H_0$ and the area under the graph

56. Each square metre of the Sun’s surface emits $S$ joules per second. The radius of the Sun is $r$, and the Sun is at a mean distance $R$ from the Earth. Which of the following gives the solar power incident per unit area of the top layer of the Earth’s atmosphere?

A. $\left( \frac{r}{R} \right)^2 S$
B. $\left( \frac{r}{R} \right)^3 S$
C. $\left( \frac{R}{r} \right)^2 S$
D. $\left( \frac{R}{r} \right)^3 S$

Assumed to radiate as a black body. The temperature of the atmosphere is $T_a$ and has an emissivity $\varepsilon$.

In the model, the intensity radiated from the ground equals the intensity radiated from the atmosphere towards the ground. What is the ratio $\frac{T_g}{T_a}$?

A. $\varepsilon^4$
B. $\varepsilon$
C. $\varepsilon^4$
D. $1$
58. A wave generator produces a power per unit length of 4.0 kW m\(^{-1}\) for waves of amplitude \(A\) and speed \(v\). The efficiency of the generator is constant. The power per unit length obtained from waves of amplitude \(2A\) and speed \(2v\) would be

A. 8.0 kW m\(^{-1}\).
B. 16 kW m\(^{-1}\).
C. 32 kW m\(^{-1}\).
D. 64 kW m\(^{-1}\).

59. The diagram shows the variation with wavelength of the power per unit wavelength \(I\) radiated from an area of 1 m\(^2\) of two different bodies.

![Graph showing variation of power per unit wavelength with wavelength]

Which of the following is a correct comparison of the temperature and of the emissivity of the two bodies?

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Emissivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. same</td>
<td>same</td>
</tr>
<tr>
<td>B. same</td>
<td>different</td>
</tr>
<tr>
<td>C. different</td>
<td>same</td>
</tr>
<tr>
<td>D. different</td>
<td>different</td>
</tr>
</tbody>
</table>

60. Which of the following is the most likely explanation for a rise in global sea level?

A. Thermal expansion of water
B. Melting of sea ice
C. Increase in rainfall
D. Thermal expansion of ice
The diagram shows an energy balance climate model for a planet.

The intensities of the reflected and radiated radiation are given in terms of the incident intensity $I$. Which of the following is the albedo of this planet?

A. 0.15
B. 0.25
C. 0.40
D. 0.60

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