

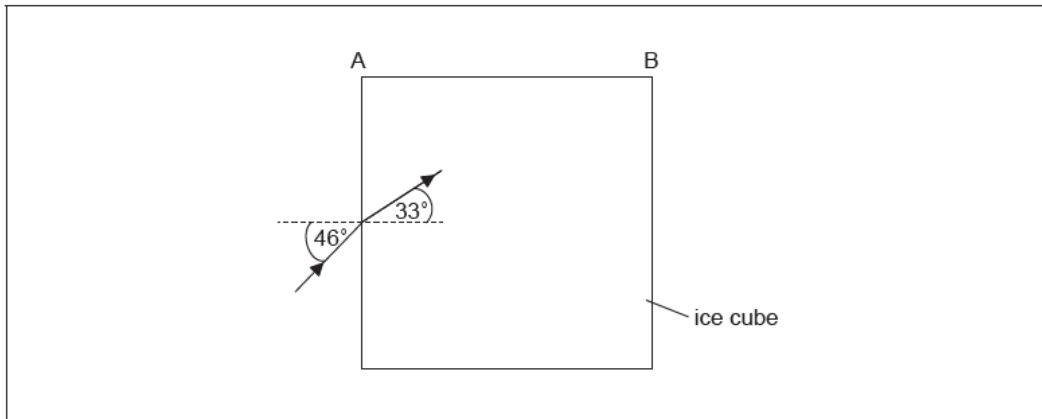
Heat Capacity [33 marks]

1. The fraction of the internal energy that is due to molecular vibration varies in the different states of matter. What gives the order from [1 mark] highest fraction to lowest fraction of internal energy due to molecular vibration?
- A. liquid > gas > solid
 - B. solid > liquid > gas
 - C. solid > gas > liquid
 - D. gas > liquid > solid

Markscheme

B

A large cube is formed from ice. A light ray is incident from a vacuum at an angle of 46° to the normal on one surface of the cube. The light ray is parallel to the plane of one of the sides of the cube. The angle of refraction inside the cube is 33° .



- 2a. Calculate the speed of light inside the ice cube.

[2 marks]

Markscheme

$$\ll V = c \frac{\sin i}{\sin r} \Rightarrow \frac{3 \times 10^8 \times \sin(33)}{\sin(46)} \gg$$

$$2.3 \times 10^8 \ll \text{m s}^{-1} \gg$$

- 2b. Show that no light emerges from side AB.

[3 marks]

Markscheme

light strikes AB at an angle of 57°

critical angle is $\llcorner \sin^{-1}\left(\frac{2.3}{3}\right) \Rightarrow 50.1^\circ$

49.2° from unrounded value

angle of incidence is greater than critical angle so total internal reflection

OR

light strikes AB at an angle of 57°

calculation showing \sin of "refracted angle" = 1.1

statement that since $1.1 > 1$ the angle does not exist and the light does not emerge

[Max 3 marks]

- 2c. Sketch, on the diagram, the subsequent path of the light ray.

[2 marks]

Markscheme

total internal reflection shown

ray emerges at opposite face to incidence

Judge angle of incidence=angle of reflection by eye or accept correctly labelled angles

With sensible refraction in correct direction

Each side of the ice cube is 0.75 m in length. The initial temperature of the ice cube is -20°C .

- 2d. Determine the energy required to melt all of the ice from -20°C to water at a temperature of 0°C .

[4 marks]

Specific latent heat of fusion of ice = 330 kJ kg^{-1}
Specific heat capacity of ice = $2.1\text{ kJ kg}^{-1}\text{ K}^{-1}$
Density of ice = 920 kg m^{-3}

Markscheme

mass = $\llcorner \text{volume} \times \text{density} \llcorner (0.75)^3 \times 920 \llcorner = 388\text{ kg} \llcorner$

energy required to raise temperature = $388 \times 2100 \times 20 \llcorner = 1.63 \times 10^7\text{ J} \llcorner$

energy required to melt = $388 \times 330 \times 10^3 \llcorner = 1.28 \times 10^8\text{ J} \llcorner$

$1.4 \times 10^8 \llcorner \text{J} \llcorner$ **OR** $1.4 \times 10^5 \llcorner \text{kJ} \llcorner$

Accept any consistent units

Award [3 max] for answer which uses density as 1000 kg^{-3} ($1.5 \times 10^8 \llcorner \text{J} \llcorner$)

- 2e. Outline the difference between the molecular structure of a solid and a liquid.

[1 mark]

Markscheme

in solid state, nearest neighbour molecules cannot exchange places/have fixed positions/are closer to each other/have regular pattern/have stronger forces of attraction

in liquid, bonds between molecules can be broken and re-form

OWTTE

Accept converse argument for liquids

[Max 1 Mark]

3. A mass m of ice at a temperature of $-5\text{ }^{\circ}\text{C}$ is changed into water at a temperature of $50\text{ }^{\circ}\text{C}$.

[1 mark]

Specific heat capacity of ice = c_i
Specific heat capacity of water = c_w
Specific latent heat of fusion of ice = L

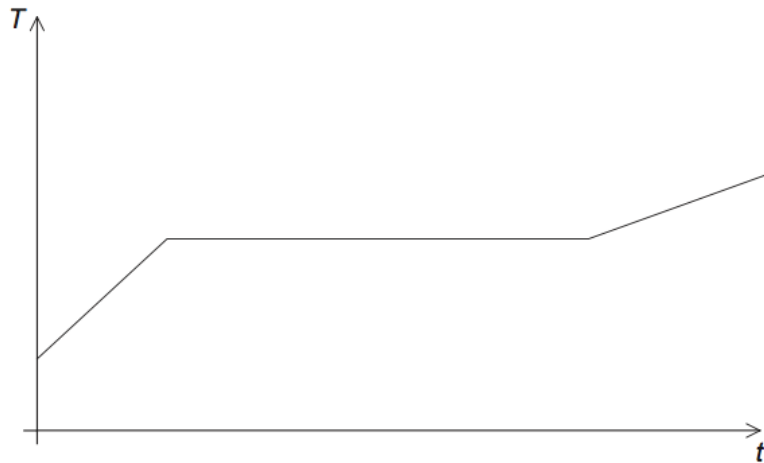
Which expression gives the energy needed for this change to occur?

- A. $55 m c_w + m L$
B. $55 m c_i + 5 m L$
C. $5 m c_i + 50 m c_w + m L$
D. $5 m c_i + 50 m c_w + 5 m L$

Markscheme

C

4. A substance is heated at constant power. The graph shows how the temperature T of the substance varies with time t as the state of the substance changes from liquid to gas. [1 mark]



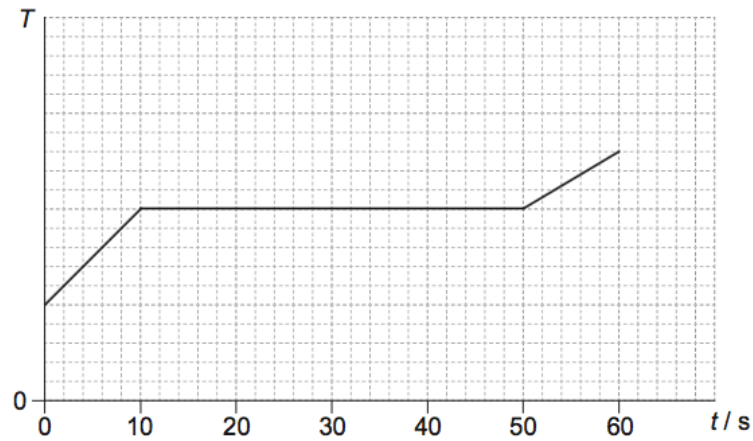
What can be determined from the graph?

- A. The specific heat capacity of the gas is smaller than the specific heat capacity of the liquid.
B. The specific heat capacity of the gas is larger than the specific heat capacity of the liquid.
C. The specific latent heat of fusion of the substance is less than its specific latent heat of vaporization.
D. The specific latent heat of fusion of the substance is larger than its specific latent heat of vaporization.

Markscheme

B

5. A container with 0.60kg of a liquid substance is placed on a heater at time $t=0$. The specific latent heat of vaporization of the substance is 200kJkg^{-1} . The graph shows the variation of the temperature T of the substance with time t . [1 mark]



What is the power of the heater?

- A. 1200 W
- B. 3000 W
- C. 4800 W
- D. 13 300 W

Markscheme

B

6. Equal masses of water at 80°C and paraffin at 20°C are mixed in a container of negligible thermal capacity. The specific heat capacity of water is twice that of paraffin. What is the final temperature of the mixture? [1 mark]
- A. 30°C
 - B. 40°C
 - C. 50°C
 - D. 60°C

Markscheme

D

7. Which of the following is equivalent to a temperature of -100°C ? [1 mark]
- A. -373 K
 - B. -173 K
 - C. 173 K
 - D. 373 K

Markscheme

C

8. A block of iron of mass 10 kg and temperature 10°C is brought into contact with a block of iron of mass 20 kg and temperature 70°C . No energy transfer takes place except between the two blocks. What will be the final temperature of both blocks? [1 mark]
- A. 30°C
B. 40°C
C. 50°C
D. 60°C

Markscheme

C

9. The specific latent heat is the energy required to change the phase of [1 mark]
- A. one kilogram of a substance.
B. a substance at constant temperature.
C. a liquid at constant temperature.
D. one kilogram of a substance at constant temperature.

Markscheme

D

10. A solid of mass m is initially at temperature ΔT below its melting point. The solid has specific heat capacity c and specific latent heat of fusion L . How much thermal energy must be transferred to the solid in order to melt it completely? [1 mark]
- A. $mL+mc$
B. $mc+mL\Delta T$
C. $mc\Delta T+L\Delta T$
D. $mc\Delta T+mL$

Markscheme

D

11. The temperature of an object is -153°C . Its temperature is raised to 273°C . What is the temperature change of the object? [1 mark]
- A. 699 K
B. 426 K
C. 153 K
D. 120 K

Markscheme

B

12. A mass of 0.20 kg of water at 20°C is mixed with 0.40 kg of water at 80°C . No thermal energy is transferred to the surroundings. What is the final temperature of the mixture? [1 mark]
- A. 30°C
B. 40°C
C. 50°C
D. 60°C

Markscheme

D

13. What is the temperature, in K, that is equivalent to 57°C ?

[1 mark]

- A. 220
- B. 273
- C. 330
- D. 430

Markscheme

C

14. The specific latent heat of a substance is defined as the energy required at constant temperature to

[1 mark]

- A. change the phase.
- B. change the phase of 1 kg.
- C. change the phase of 1 m^3 .
- D. change the phase of 1 kg every second.

Markscheme

B

15. Thermal energy is transferred to a solid. Three properties of the solid are

[1 mark]

- I. volume
- II. mass
- III. specific heat capacity.

Which of the above properties determine the rise in temperature of the solid?

- A. I and III only
- B. II and III only
- C. II only
- D. III only

Markscheme

B

16. A pure solid is heated at its melting point. While it is melting the

[1 mark]

- A. mean kinetic energy of the molecules of the solid increases.
- B. mean potential energy of the molecules of the solid increases.
- C. temperature of the solid increases.
- D. temperature of the solid decreases.

Markscheme

B

17. A liquid-in-glass thermometer is in thermal equilibrium with some hot water. The thermometer is left in the water. The water cools to the temperature of the surroundings. Which of the following is **unlikely to be true** for the thermometer? [1 mark]

- A. It is in thermal equilibrium with the water.
- B. It is in thermal equilibrium with the surroundings.
- C. It is at the same temperature as the water.
- D. It has the same thermal capacity as the water.

Markscheme

D

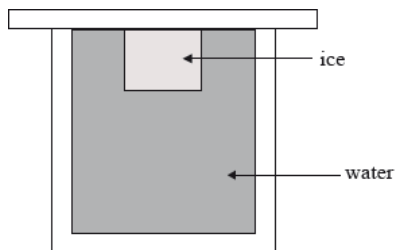
18. An ice cube and an iceberg are both at a temperature of $0\text{ }^{\circ}\text{C}$. Which of the following is a correct comparison of the average random kinetic energy and the total kinetic energy of the molecules of the ice cube and the iceberg? [1 mark]

	Average random kinetic energy	Total kinetic energy
A.	same	same
B.	same	different
C.	different	same
D.	different	different

Markscheme

B

19. Water at a temperature of $0\text{ }^{\circ}\text{C}$ is kept in a thermally insulated container. A lump of ice, also at $0\text{ }^{\circ}\text{C}$, is placed in the water and completely submerged. [1 mark]



Which of the following is true in respect of both the net amount of ice that will melt and the change in temperature of the water?

	Net amount of ice that melts	Change in temperature of water
A.	all will melt	no change
B.	some will melt	decrease
C.	none will melt	no change
D.	all will melt	decrease

Markscheme

C

20. Tanya heats 100 g of a liquid with an electric heater which has a constant power output of 60 W . After 100 s the rise in temperature is 40 K . The specific heat capacity of the liquid in $\text{J kg}^{-1}\text{K}^{-1}$ is calculated from which of the following? [1 mark]

- A. $\frac{60 \times 100}{0.1 \times 40}$
B. $\frac{60 \times 0.1}{40}$
C. $\frac{0.1 \times 40}{60}$
D. $\frac{60}{40}$

Markscheme

A

21. In the table below, which row shows the correct conversion between the Kelvin and Celsius temperature scales?

[1 mark]

	Kelvin temperature / K	Celsius temperature / °C
A.	0	373
B.	100	-173
C.	173	100
D.	373	-100

Markscheme

B

22. A temperature of 23 K is equivalent to a temperature of

[1 mark]

- A. -300 °C.
- B. -250 °C.
- C. +250 °C.
- D. +300 °C.

Markscheme

B