Exercise I.1.1 Answers

1. Solid, Liquid, Gas, Plasma

2. Any from the following examples or similar

A. Ice, metal, wood, or any other solid and ridged material that does not flow
B. The sun, lightning, the gas in a fluorescent strip light, the gas in a plasma T.V
C. Water, the sea, liquid mercury, and any other substance that flows and takes on the shape of the container that holds it
D. the atmosphere, helium in a balloon, steam from a kettle etc.

3.
A. Freezing
B. Vaporisation
C. Condensation
D. Sublimation

4.
A. In the liquid form the water molecules have enough energy to allow the molecules to move over each other and flow. The water molecules are arranged in a moving random order. As the temperature reduces the water freezes. The particle energy has reduced with temperature, and is no longer sufficient to overcome the intermolecular forces between nearest neighbors. The molecules become fixed, arranged with a higher degree of ordering, held firmly in place by the bonds between it and its nearest neighbors. The molecules can now only vibrate about their fixed points.

B. In the form of steam, the force between molecules is easily overcome by the energy of the molecules. Thus the steam molecules are free to move in random motion, and there is a large separation between molecules. As the steam touches the mirror (which is much colder than the steam) heat energy is transferred from the gas molecules to the mirror. The particles loose energy, and intermolecular bonds between molecules become significant. The molecules condense onto the mirror forming liquid droplets, the molecules packing closer together but with enough energy to allow them to move around their nearest neighbors whilst remaining in contact with each other.

Challenge Question

5.

Solid	Gas
Particles are held in a fixed place	Particles are free to move
Particles have low energy	Particles have high energy
Substance has high density	Substance has low density
Fixed volume and shape	No fixed shape or volume

Exercise I.1.2

1.
$T_{initial}$ = 20°C
ΔT = 50°C

(a) $T_{final} = T_{initial} + \Delta T$ = 20°C + 50°C = 70°C

(b)
$T_{initial}$ = 20°C = 20 + 273.15 = 293.15 = 293°K
T_{final} = 70°C = 70 + 273.15 = 343.15 = 343°K

(c) An increase of 1°C is the same as an increase of 1°K since an increment is the same on both scales. The increase in temperature is therefore 50°K.

2.
i. 27°C = 27 + 273.15 = 300.15 = 300°K
ii. 110°C = 110 + 273.15 = 383.15 = 383°K
iii. -80°C = -80 + 273.15 = 193.15 = 193°K

3.
i. 53°K = 53 – 273.15 = -220.15 = -220°C
ii. 300°K = 300 – 273.15 = 26.85 = 27°C
iii. 10°K = 10 – 273.15 = -263.15 = -263°C

4. The internal energy of a substance (sometimes referred to as the thermal energy) is the sum of the energies of the individual particles making up the substance. The particle energies are the result of movement of the particles (kinetic) and the forces between particles (potential).

B. Snow
C. Liquid water
A. Fog
D. Steam

Challenge Question

5. Any situation where the energy is transferred to the object at the same rate as the object looses or radiates energy to the surroundings.

Exercise I.1.3

1. The specific heat capacity of an object is defined as the energy required to raise the temperature of 1kg of a substance by 1°K

2.
C. 2kg lead block
D. 2kg block of marble
A. 2.4kg of tap water in an aluminium bucket
B. 6kg of tap water in an aluminium bucket

3. $c = 850 Jkg^{-1}K^{-1}$, ΔE = 30000J , $\Delta T = 4$°C. $E = mc\Delta T$, therefore

$$m = \frac{E}{c\Delta T} = \frac{30000J}{850 \times 4} = 8.82kg$$

4. m = 600,000kg, $c = 4190 Jkg^{-1}K^{-1}$, ΔT = 2°C.

$$E = mc\Delta T = 600{,}000kg \times 4190 \times 2 = 5.028 \times 10^9 J = 5028MJ$$

5028 × 0.06 = £301.68

Challenge Question

5. A power supply provides a current of 6A to a 6V heating element inserted into a well-insulated beaker of water. The supply is switched on for 4 minutes. If the water in the beaker has a mass of 0.5kg and the final temperature of the water is 72°C, calculate the initial temperature to the nearest degree given that the specific heat capacity of water is $4190 Jkg^{-1}K^{-1}$.

I = 6A
V = 6V
t = 4 minutes = 4 × 60 = 240s
m = 0.5kg
T_f = 72°C
$c = 4190 Jkg^{-1}K^{-1}$

Total electrical energy transferred in a time t in Joules is IVt . Therefore

$$IVt = mc\Delta T$$

Rearranging for ΔT we obtain

$$\Delta T = \frac{IVt}{mc}$$

Since $\Delta T = T_f - T_i$

$$T_f - T_i = \frac{IVt}{mc}$$

Therefore

$$T_i = -\left(\frac{IVt}{mc}\right) + T_f = -\left(\frac{6 \times 6 \times 240}{0.5 \times 4190}\right) + 72 = -4.12 + 72 = 67.88℃$$