Mark scheme for Extension Worksheet – Topic 3, Worksheet 1

1 Internal energy is the complete sum of the random kinetic energy and intermolecular potential energy of the molecules of a substance; whereas heat is energy that gets transferred from one body into another as a result of a difference of temperature. [2]

2 **a** The 5.0 kg body; because it has more mass i.e. more molecules and higher temperature. [2]

b From the 600 K body to the 300 K body. [1]

3 **a** It will be the same because of energy conservation, whatever energy one body gives away the other will receive. [1]

b It will be different because the two bodies have different specific heat capacities

$(mc_{\text{iron}}\Delta\theta_{\text{iron}} = mc_{\text{copper}}\Delta\theta_{\text{copper}}$ so $\frac{\Delta\theta_{\text{iron}}}{\Delta\theta_{\text{copper}}} = \frac{c_{\text{copper}}}{c_{\text{iron}}})$ [1]

4 $300 \times c_{\text{water}} \times (T - 20^{\circ}) = 600 \times c_{\text{water}} \times (80^{\circ} - T)$ hence $T - 20^{\circ} = 160^{\circ} - 2T$, i.e. $T = 60^{\circ}$ [1]

Many students would solve this by arguing that the difference in initial temperature i.e. $80^{\circ} - 20^{\circ} = 60^{\circ}$ would be ' split' in the ratio of 2 to 1 (the ratio of the masses) to become 40° and 20°. So the cold body will now have a temperature of $20^{\circ} + 40^{\circ} = 60^{\circ}$ and the hot body a new temperature of $80^{\circ} - 20^{\circ} = 60^{\circ}$. It is preferable and safer to use the first method!

5 Let the mass of water be *M*, the mass of the ice cube be *m* and the initial temperature of the ice cube be θ_0 below zero Celsius. Then from the first case we know that $mc_{ice}\theta_0 + mL + mc_{water}15 = Mc_{water}5$ and so we deduce that $mc_{ice}\theta_0 + mL = Mc_{water}5 - mc_{water}15$. For the second case $mc_{ice}\theta_0 + mL + mc_{water}T = Mc_{water}(40 - T)$ where *T* is the new final temperature. So $Mc_{water}5 - mc_{water}15 + mc_{water}T = Mc_{water}(40 - T)$ i.e.

$$(m + M)T = 35M + 15m$$

$$T = \frac{35M + 15m}{M + m}$$

$$40 - T = 40 - \frac{35M + 15m}{M + m} = \frac{5M + 25m}{M + m} = 5 + \frac{20m}{M + m}$$

which shows that the drop in temperature will be larger than 5 ℃, so **C** [1]

6 **a**

$0.020\times 2100\times 10+0.020\times 334\times 10^{3}+0.020\times 4200T=0.250\times 4200\times (20-T)$

so the new temperature of the water is $T=12.26\approx 12\ ^{\circ}\text{C}$ [2]

b Now the second ice cube is put in so:

$0.020\times 2100\times 10+0.020\times 334\times 10^{3}+0.020\times 4200T=0.270\times 4200\times (12.26-T)$

which gives $T=5.58\approx 5.6\ ^{\circ}\text{C}$ [2]

c With two ice cubes dropped in at the same time:

$0.040\times 2100\times 10+0.040\times 334\times 10^{3}+0.040\times 4200T=0.250\times 4200\times (20-T)$

and so $T=5.58\approx 5.6\ ^{\circ}\text{C}$ [2]

d The two answers are the same. [1]

7 The energy provided has gone into increasing the intermolecular potential energy of the molecules which are further apart in the vapour phase; no energy has gone into random kinetic energy of the molecules and so no change in temperature has come about. [2]

8 The fastest molecules form the surface of the liquid escape the liquid leaving behind the slower molecules; the average kinetic energy of the molecules decreases and so does the temperature since temperature is a measure of the average kinetic energy of the molecules. [2]

9 **a** It takes 140 s to warm the paraffin from 20 °C to 48 °C; and so

$P=mc\dfrac{\Delta\theta}{\Delta t}=0.120\times 2500\times \dfrac{28}{140}=60\text{W}$ [2]

b The constant temperature at which paraffin melts is 48 °C; [1]

c It takes the paraffin $560-140=420\text{ s}$ to melt, the energy provided is $Q=Pt=60\times 420=25200\text{ J}$; and so the specific latent heat of fusion is

$L=\dfrac{Q}{m}=\dfrac{25200}{0.120}=2.1\times 10^{5}\text{ J kg}^{-1}$ [2]

d It takes an additional $610-560=50\text{ s}$ to warm liquid paraffin at 48 °C to a temperature of 60 °C; and so

$P=mc\dfrac{\Delta\theta}{\Delta t}=0.120\times c\times \dfrac{60-48}{50}\Rightarrow c=\dfrac{60\times 50}{12\times 0.120}=2.1\times 10^{3}\text{ J kg}^{-1}\text{ K}^{-1}$ [2]

e The temperature stays constant even though energy is provided because the energy is used to separate the molecules thus increasing their intermolecular potential energy; no energy goes into kinetic energy and so the temperature does not change. [2]

10 **a** The hot piece of tungsten is assumed to have the temperature of the flame T and when transferred to the calorimeter loses heat. The heat lost is
$Q = mc\Delta\theta = 0.150\times1.3\times10^2\times(T-52)$; this heat is gained by the calorimeter
$0.120\times9.1\times10^2\times(52-22) = 3276$ J and the water
$0.300\times4.2\times10^3\times(52-32) = 37800$ J so that
$0.150\times1.3\times10^2\times(T-52) = 41076$; and so $T = 2158 \approx 2160\ ^{\circ}\mathrm{C}$ [3]

b Some energy must have been lost to the surroundings during the transfer; so the actual flame temperature must be higher. [2]

