Mark scheme for Topic 3

1 Since the temperature is the same and temperature is proportional to the average kinetic energy of the molecules, the ratio is 1, **A**.

2 Temperature determines the direction of energy flow and so there can be no net energy transfer between the bodies, **B**.

Exam tip: We cannot claim that there will be absolutely no transfer of energy between the bodies as fluctuations will always change the temperature locally by minute amounts.

3 The temperature stays constant, so **D** is out. The reason for any pressure increase is collisions of molecules with the walls, not with each other. With a smaller volume the collisions with the walls are more frequent, so **C**.

4 $Q = mc\Delta\theta$ and so $P = mc\frac{\Delta\theta}{\Delta t} = mcr$. Hence $c = \frac{P}{mr}$, **A**.

5 **a** **i** The ability to have energy flow from one body to the other. **[1]**

ii The temperature of the bodies: energy will flow from the hot to the colder body. **[1]**

b **i** The energy lost by the hot body will equal the gain in energy by the other, and so the changes in internal energy will have the same magnitude. **[1]**

Exam tip: the changes in internal energy must be the same from the law of conservation of energy. The changes in temperature depend on specific heat capacities.

ii Since the bodies have different specific heat capacities, the change in temperature for each body will be different. **[2]**

6 **a** **i** Without air resistance forces the graph would have been a straight line (because the acceleration would then be constant),

and the graph here is a curve. **[2]**

ii The height from which the body drops is the area under the curve

and is about 140 m (by counting squares; each square has an area of $1\times1=1\,\text{m}$ and there are about 140 full squares). **[2]**

iii The speed the body should have, if there were no air resistance, is $\frac{1}{2}mv^2=mgh \Rightarrow v=\sqrt{2gh}$

$v=\sqrt{2\times9.8\times140}=52\ \text{m}\,\text{s}^{-1}$. **[2]**

Exam tip: a common mistake here would be to use the time of fall of 10 s to claim that the speed would be $gt=10\times10=100\ \text{m}\,\text{s}^{-1}$. This is not true since we have air resistance and the time would be different.

b The impact speed of the body is about $17\ \text{m}\,\text{s}^{-1}$ and so the kinetic energy 'lost' is $\frac{1}{2}\times8.0\times(52^2-17^2)\approx9.7\ \text{kJ}$,

Assuming that **all** of this energy goes into thermal energy in the body (and not the surroundings),

and that the body is heated uniformly,

$8.0\times320\times\Delta\theta\approx9.7\times10^3\ \text{J}\Rightarrow\Delta\theta=\frac{9.7\times10^3}{8.0\times320}\approx4\,\text{K}.$ **[4]**

Exam tip: you must make this assumption, otherwise you cannot do the problem.

7 **a** The energy required to increase the temperature of a unit mass by one degree. **[1]**

b Energy lost by hot metal is $0.150\times 130\times (T-31)$. Energy gained by calorimeter and water is

$(0.300\times 4200+0.120\times 910)\times (31-22)=12323\text{ J}$.

Exam tip: do not forget the calorimeter!

Hence, $0.150\times 130\times (T-31)=12323$, $T-31=\dfrac{12323}{0.05\times 130}=1896\ ^{\circ}\text{C}$

$T=1.9\times 10^{3}\ ^{\circ}\text{C}$. **[3]**

c Some of the energy must have been transferred to the air while moving the metal from the flame to the water.

Hence the actual energy in the numerator of the last equation should have been larger. The actual temperature will be larger than the answer in **b**. **[2]**

8 **a** **i** The statement is not correct because when a solid melts its internal energy increases (because the intermolecular potential energy increases).

But the temperature stays the same. **[2]**

ii If the student were correct, an ice cube and an iceberg at 0° C would have the same internal energy.

But the iceberg has many more molecules and so greater internal energy. **[2]**

Exam tip: what the ice cube and iceberg have in common is the same **average random kinetic energy** of their molecules.

b **i** It must be that the rate of loss of energy from the liquid

equals the rate at which energy is being provided to the liquid. **[2]**

ii The rate of loss of energy from the liquid is $\frac{\Delta Q}{\Delta t} = mc\frac{\Delta \theta}{\Delta t} = 0.240c \times \frac{3.1}{60}$.

The rate of loss must equal the rate at which the liquid was heated, i.e. 35 W, hence $0.240c \times \frac{3.1}{60} = 35$.

$c = 2.8 \times 10^3$ J kg^{-1} K^{-1}. **[3]**

