Mark schemes

1

(a) (use of $\Delta Q = mc\Delta T$ gives) $\Delta Q = 0.45 \times 4200 \times (35 - 15)$ **(1)**

$= 3.8 \times 10^4$ J (3.78×10^4 J) **(1)**

2

(b) (i) 3.8×10^4 J **(1)**
(allow C.E. for incorrect value of ΔQ from (a))

(ii) ($mc\Delta T = \Delta Q$ gives) $0.12 \times 390 \times \Delta T = 3.8 \times 10^4$ **(1)**
$\Delta T = 812$ K **(1)**
(use of $\Delta Q = 3.78$ gives $\Delta T = 808$ K
(allow C.E. for incorrect value of ΔQ from (i))

(iii) (812 + 35) = 847 ºC **(1)**
(use of 808 gives 843 ºC)
(allow C.E. from (ii))

4

[6]

2

(a) (i) (use of $n = \frac{pV}{RT}$ gives) $n = \frac{1.0 \times 10^5 \times 1.0}{8.31 \times 300}$ **(1)**

= 40(.1) moles **(1)**

(ii) $n = \frac{2.2 \times 10^4 \times 1.0}{8.31 \times 270}$ = 9.8**(1)** moles **(1)**

3

(b) (total) $= (40 \times 6 \times 10^{23}) - (9.8 \times 6 \times 10^{23}) = 1.8(1) \times 10^{25}$ **(1)**

(allow C.E. for incorrect values of n from (a))

(oxygen molecules) $= 0.23 \times 1.8 \times 10^{25} = 4.2 \times 10^{24}$ **(1)**

2

[5]

3

(a) (i) curve A below original, curve B above original **(1)**

(ii) both curves correct shape **(1)**

2

(b) (i) (use of $pV = nRT$ gives) $130 \times 10^3 \times 0.20 = n \times 8.31 \times 290$ **(1)**

$n = 11$ (mol) **(1)** (10.8 mol)

(ii) (use of $E_k = \frac{3}{2}kT$ gives) $E_k = \frac{3}{2} \times 1.38 \times 10^{-23} \times 290$ **(1)**

$= 6.0 \times 10^{-21}$ J **(1)**

(iii) (no. of molecules) $N = 6.02 \times 10^{23} \times 10.8$ (= 6.5×10^{24})
total k.e. = $6.5 \times 10^{24} \times 6.0 \times 10^{-21} = 3.9 \times 10^4$ J **(1)**
(allow C.E. for value of n and E_k from (i) and (ii))
(use of $n = 11$ (mol) gives total k.e. = 3.9 (7) $\times 10^4$ J)

5

[7]

4 (a) (i) a collision in which kinetic energy is conserved **(1)**

(ii) molecules of a gas are identical
[or all molecules have the same mass] **(1)**
molecules exert no forces on each other except during impact **(1)**
motion of molecules is random
[or molecules move in random directions] **(1)**

volume of molecules is negligible (compared to volume of container)
[or very small compared to volume of container or point particles] **(1)**
time of collision is negligible (compared to time between collisions) **(1)**
Newton's laws apply **(1)**
large number of particles **(1)** (any two)

3

(b) (i) the hot gas cools and cooler gas heats up
until they are at same temperature
hydrogen molecules transfer energy to oxygen molecules
until **average k.e.** is the same
(any two **(1) (1)**)

(ii) (use of $E_k = \frac{3}{2}kT$ gives) $E_k = \frac{3}{2} \times 1.38 \times 10^{-23} \times 420$ **(1)**

$= 8.7 \times 10^{-21}$ J (8.69×10^{-21} J)

4

[7]

5 (a) (i) energy = $800 \times 60 = 48 \times 10^3$J **(1)**

(ii) (use of $\Delta Q = mc\Delta\theta$ gives) $48 \times 10^3 = 60 \times 3900 \times \Delta\theta$ **(1)**
$\Delta\theta = 0.21$ K **(1)** (0.205 K)
(allow C.E. for value of energy from (i)) 3

(b) $\Delta Q = ml$ gives 500 × 60 **(1)** = m × 2.3 × 10^6 **(1)**
m = 0.013 kg **(1)**

3

(c) not generating as much heat internally **(1)**
still losing heat (at the same rate)
[or still sweating] **(1)**
hence temperature will drop **(1)**

lmax 2

[8]

6 (a) (i) mass each sec [=(vol / sec) × density] = 5.2 × 10^{-5} × 1000 **(1)**
= 0.052 kg (s^{-1}) **(1)**

(ii) power (= energy supplied per sec = $mc\Delta\theta$) = 0.052 × 4200 × (42 - 10) **(1)**
= 7.0 × 10^3W **(1)** (6.99 × 10^3W)

(allow C.E. for value of mass each sec from (i)

4

(b) $h = ½gt^2$ gives the time to reach the floor **(1)**

$$t\left(=\left(\frac{2h}{g}\right)^{1/2}\right)=\left(\frac{2\times 2.0}{9.8}\right)^{1/2}$$ = 0.64s **(1)** (0.639 s)

range = (horizontal) speed of projection × time = 2.5 × 0.64 = 1.6 m **(1)**
(allow C.E. for value of t)

3

[7]

7 D

[1]

8 B

[1]

9 A

[1]

10 D

[1]

Examiner reports

1 Many candidates scored full marks in this question. Less able candidates created the usual confusion between the Kelvin and Celsius scale, but this was less of an issue than has been the case in the past. Candidates are clearly benefiting from practice with thermal energy questions.

2 Again many candidates scored high marks in this question. There was a tendency to incur a significant figure penalty for either quoting an answer to too many significant figures or rounding down to one significant figure. Part (b) caused problems for less able candidates who, although correctly determining the change in number of moles, were then either unable to calculate 23% of the number or else did not multiply the change in number of moles by Avogadro's number.

3 Candidates found this question quite demanding and although in part (a) most were able to draw the two graphs correctly, the answers were spoilt due to a lack of care in the sketches.

The calculations in part (b) were more discriminating and arithmetic errors were common. The correction to part (b) (iii) did not seem to cause problems, although only the more able candidates were able to come up with a correct response. A significant proportion of candidates answered the question correctly but then lost the final mark due to a significant figure penalty.

4 Candidates answered this question confidently although there was still some confusion as to acceptable assumptions made in the kinetic theory. The term 'thermal equilibrium' did cause some confusion to weaker candidates but full marks for this question were quite common.

5 Questions involving thermal energy have caused problems for candidates in previous papers, but this question was well answered. It also proved to be a good discriminator. Weaker candidates did have problems, however, in structuring their calculations in a logical way, leading to errors in the final answers.

The explanation in part (c) was answered well by good candidates who, in some cases, provided considerable detail which was worthy of more than the two marks allocated.

6 A large majority of the candidates gained full credit in part (a) (i) and were able to calculate the power correctly. However, the temperature difference confused other candidates, not realising that the temperature difference in °C is the same as in Kelvins. Some candidates lost the final mark as a result of a significant figure error or giving the power in joules and not watts or joules per second. Arithmetical errors leading to grossly unrealistic answers were made by a few candidates.

In part (b), the time of descent needed to be calculated from the height drop in order to determine the horizontal distance travelled. Many candidates were able to do this correctly. Other candidates failed to gain any credit as a result of attempting to bring the speed of projection into the calculations for time of descent and the horizontal distance.