1. (a) gas that obeys the equation $pV = nRT$ / no forces between molecules;
at all pressures, volumes and temperatures / or any other postulate; 2

(b) (i) $pV = nRT$
$20 \times 10^{6} \times 2 \times 10^{-2} = n \times 8.3 \times 290$;
$n = 170$ (166); 2

(ii) number $= n \times N_A$;
number $= 166 \times 6.02 \times 10^{23} = 1.0 \times 10^{26}$; 2

[6]

2. (a) more energetic molecules leave surface;
mean kinetic energy of molecules in liquid decreases;
and mean kinetic energy depends on temperature; 3

*Award **[2]** if mean not mentioned.*

(b) *e.g.* <u>larger</u> surface area;
<u>increased</u> draught;
<u>higher</u> temperature;
<u>lower</u> vapour pressure; 2 max

*Award **[1]** if candidate merely identifies two factors.*

(c) energy to be extracted $= 0.35 \times 4200 \times 25$;
$+0.35 \times 330\,000$;
$+0.35 \times 2100 \times 5$;
$= 156\,000$ J

time $= \dfrac{156\,000}{86} = 1800$ s; 4

Allow ECF if one term incorrect or missing.

[9]

3. (a) (165, 0); 1

(b) *Look for these points:*
to change phase, the separation of the molecules must increase;

Some recognition that the ice is changing phase is needed.

so all the energy input goes to increasing the PE of the molecules;

Accept something like "breaking the molecular bonds".

KE of the molecules remains constant, hence temperature remains constant; 3

If KE mentioned but not temperature then assume they know that temperature is a measure of KE.

(c) (i) time for water to go from 0 to 15° C = 30 s;
energy required $= ms\Delta\theta = 0.25 \times 15 \times 4\,200 = 15\,750$ J;
power $= \dfrac{\text{energy}}{\text{time}} = 525 \text{ W} \approx 530$ W; 3

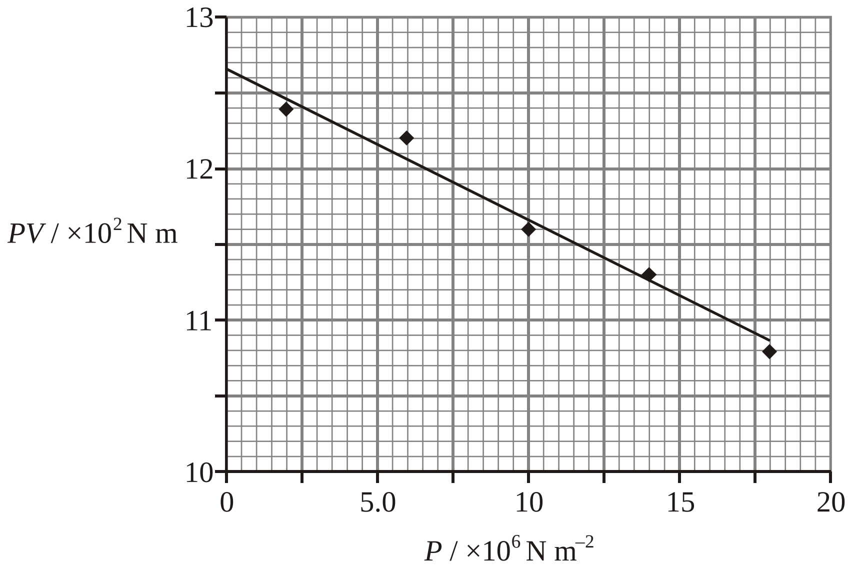
(ii) ice takes 15 s to go from – 15 °C to 0;
energy supplied $= 15 \times 530$ J;
sp ht $= \dfrac{(530 \times 15)}{(15 \times 0.25)} = 2100 \text{ J kg}^{-1} \text{ K}$; 3

(iii) time to melt ice = 150 s;

$L = \frac{(150 \times 530)}{0.25} = 320\ \text{kJ kg}^{-1}$; 2

[12]

4.



(a) suitable straight-line of best fit; 1

(b) *A* is the intercept on the *y*-axis consistent with line drawn (or by implication);
= 12.6 = 1.3×10^3 N m the best fit line should give a 2 SD value of 1.3×10^3 N m;
B is the gradient;
some evidence that reasonable values have been used ($y_2 - y_1 > 0.9$, $x_2 - x_1 > 8$);

*Accept answers based on using two data points on line. Award **[3 max]** if points not on line. Ignore any missing units and do not penalize if minus sign is omitted. Award **[1]** for determination of B if only one data point is used.*

(c) $B = 0$; 1

(d) (i) substitute into $PV = A + BP$
$PV = 1300 - (1.0 \times 10^{-5} \times 6.0 \times 10^7)$;
= 700(640 → 760) N m;
= $1.9(0.5) \times 10^3$ N m *if BP is added instead of subtracted.*
Award [1] for ECF.

(ii) recognize that the ideal gas value is the intercept on the *y*-axis;
or
from $PV = RT$;
or
= constant A;
difference 600(540 → 660) Nm; 2

[11]

5. (a) ***[1]** for each appropriate and valid point e.g.*
thermal energy is the K.E. of the component particles of an object;
thus measured in joules;
the temperature of an object is a measure how hot something is (it can be used to work out the direction of the natural flow of thermal energy between two objects in thermal contact) / measure of the average K.E. of molecules;
it is measured on a defined scale (Celsius, Kelvin *etc*.); 4 max

(b) (i) correct substitution: energy = power × time;
= 1200 W × (30 × 60) s;
= 2.2 × 10 J 2 max

(ii) use of $E = m\,c\,\Delta\theta$;
to get $\Delta\theta = 2.2 \times 10^6 / (4200 \times 70)$ K;
$= 7.5$ K; 3 max

(c) ***[1]** naming each process up to **[3 max]**.*
convection;
conduction;
radiation;

***[1]** for an appropriate (matching) piece of information / outline for each process up to **[3 max]**.*

e.g. convection is the transfer of thermal energy via bulk movement of a gas due to a change of density;
conduction is transfer of thermal energy via intermolecular collisions;
radiation is the transfer of thermal energy via electromagnetic waves (IR part of the electromagnetic spectrum in this situation) */ OWTTE*; 6 max

(d) (i) ***[1]** for each valid and relevant point e.g.*
in evaporation the faster moving molecules escape;
this means the average K.E. of the sample left has fallen;
a fall in average K.E. is the same as a fall in temperature; 3 max

(ii) energy lost by evaporation = 50 % × 2.2×10^6 J;
= 1.1×10^6 J;
correct substitution into $E = m\,l$
to give mass lost = $1.1 \times 10^6\ \text{J} / 2.26 \times 10^6\ \text{J kg}^{-1}$
= 0.487 kg
= 487 g; 3 max

(iii) ***[1]** for any valid and relevant factors **[2 max]** e.g.*
area of skin exposed;
presence or absence of wind;
temperature of air;
humidity of air *etc*.;

***[1]** for appropriate and matching explanations **[2 max]** e.g.*
increased area means greater total evaporation rate;
presence of wind means greater total evaporation rate;
evaporation rate depends on temperature difference;
increased humidity decreases total evaporation rate *etc*.; 4 max

[25]