1. (a) increase in the degree of disorder (in the system); 1

(b) total entropy (of the universe); is increasing; 2

(c) entropy of surroundings increases by a greater factor;
because process gives off thermal energy / other appropriate statement; 2

[5]

2. (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;

$\text{power} = \frac{\text{energy}}{\text{time}} = 525 \text{ W} \approx 530 \text{ W}$; 3

(ii) ice takes 15 s to go from –15 °C to 0;
energy supplied = 15 × 530 J;

$\text{sp ht} = \frac{(530 \times 15)}{(15 \times 0.25)} = 2100 \text{ J kg}^{-1} \text{ K}^{-1}$; 3

(iii) time to melt ice =150 s;

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

(d) the degree of disorder/order (of the molecules of the ice); 1

(e) in any process, (reaction, event *etc*.) the overall entropy of the universe/a closed system increases ; 1

(f) entropy decreases;
*Award **[1]** each for any of these main points, up to **[3 max]**.*

when water freezes it gives out energy (heat);
therefore speed (KE) of surrounding air molecules increases;
the air surrounding the ice is therefore in a more disordered state;
therefore disorder (entropy) of the universe increases; 4 max

[18]

3. (a) statement (implication) that work done is associated with area <u>within the rectangle</u>;
Do not award mark for just "area" without reference.

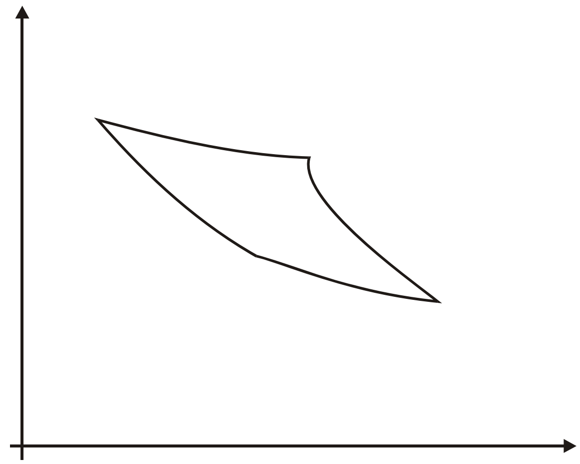
calculation of $2 \times 10^5 \times 8 = 1.6 \times 10^6$ J; 2 max

(b) thermal energy from hot reservoir = $1.8 \times 10^6 + 1.6 \times 10^6$ J
$= 3.4 \times 10^6$ J;

efficiency = work done / thermal energy from hot reservoir
$= 1.6 \times 10^6 / 3.4 \times 10^6$
$= 47$ %; 2 max

[0] for $1.6 \times 10^6 / 1.8 \times 10^6 = 89$ %.

(c) closed cycle of rough approximate shape;
quality of diagram (adiabatic "steeper" than isothermal *etc.*); 2 max



(d) (i) adiabatic (expansion and contraction);
isothermal (expansion and contraction); 2 max

(ii) correct "sense" of adiabatic followed by and isothermal *etc.*;
e.g. adiabatic (expansion) then
isothermal (contraction) then
adiabatic (contraction) then
isothermal (expansion) then
correct identification of adiabatic as the steeper curve when compared with isothermal; 2 max

[10]

4. (a) isothermal: takes place at constant temperature;
adiabatic: no energy exchange between gas and surroundings; 2

(b) (i) neither; 1

(ii) $\Delta W = P\Delta V = 1.2 \times 10^5 \times 0.05 = 6.0 \times 10^3$ J; 1

(iii) recognize to use $\Delta Q = \Delta U + \Delta W$;
to give $\Delta U = 2.0 \times 10^3$ J; 2

[6]

5. (a) momentum of object = $2 \times 10^3 \times 6.0$;
momentum after collision = $2.4 \times 10^3 \times v$;
use conservation of momentum, $2 \times 10^3 \times 6.0 = 2.4 \times 10^3 \times v$;
to get $v = 5.0$ m s^{-1}; 4

*Award **[2 max]** for mass after collision = 400 kg and v = 30 m s^{-1}.*

(b) KE of object and bar + change in PE = $1.2 \times 10^3 \times 25 + 2.4 \times 10^3 \times 10 \times 0.75$;
use $\Delta E = Fd$, $4.8 \times 10^4 = F \times 0.75$;
to give F =64 kN;
*Award **[2 max]** if PE missed, F = 40 kN.*
or
$a = \frac{v2}{2s}$;
$F - mg = ma$;
to give F = 64 kN; 3
*Award **[2 max]** if mg missed.*

(c) recognize that the height is given by $mgh = \frac{1}{2}mv^2$;

$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2.0 \times 10^3 \times 36 = 3.6 \times 10^4$ J;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3}$ =5.0 s;
or
calculation of $PE = mgh$ using $v^2 = u + 2as$
h = 1.8 m;
$mgh = 2.0 \times 10^3 \times 10 \times 1.8$;

$t = \frac{E}{P}$;

$= \frac{3.6 \times 10^4}{7.2 \times 10^3}$ = 5.0 s; 4

(d) (i) a process in which there is no energy (heat) exchange;
between system and surrounding;
or
all the work done;
either increases or decreases the internal energy of the system; 2

(ii) a process that takes place at constant volume; 1

(iii) a process that takes place at constant pressure; 1

(e) (i) adiabatics: C $\rightarrow$ D, A $\rightarrow$ B; 1

(ii) isochoric: D $\rightarrow$ A; 1

(iii) isobaric: B $\rightarrow$ C; 1

(f) work done in one cycle; 1

(g) $\frac{8400}{40}$ = 210 J; 1

(h) $Eff = \frac{W}{Q_H}$;

therefore, $Q_H = \frac{210}{0.4} = 525$ J; 2

[22]