Thermal exam questios MS

1

(a) the number of atoms in 12g of carbon-12   
or the number of particles / atoms / molecules in one mole of substance ✓

*not – NA quoted as a number*

**1**

(b) (i) mean kinetic energy ( = 3 / 2 *kT*) = 3 / 2 × 1.38 × 10−23 × (273 + 22)   
= 6.1 × 10−21 (J) ✓

*6 × 10−21 J is not given mark*

**1**

(ii) mass of krypton atom   
= 0.084 / 6.02 × 10+23 ✓   
( = 1.4 × 10−25 kg)   
http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS14503_files&file=img01.png( = 2 × mean kinetic energy / mass   
  
= 2 × 6.1 × 10−21 / 1.4 × 10−25)   
= 8.7 - 8.8 × 104 ✓   
m2 s−2 or J kg−1 ✓

*1st mark is for the substitution which will normally be seen within a larger calculation.   
allow CE from (i)   
working must be shown for a CE otherwise full marks can be given for correct answer only   
no calculation marks if mass has a physics error i.e. no division by NA note for CE   
answer = (i) × 1.43 × 1025*

**3**

(c) (at the same temperature) the mean kinetic energy is the same   
or   
gases have equal http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS14503_files&file=img02.png  
or   
mass is inversely proportional to mean square speed / m ∝ 1 http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS14503_files&file=img03.png✓   
http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS14503_files&file=img01.pngor mean square speed of krypton is less ✓

*1st mark requires the word mean / average or equivalent in an algebraic term   
2nd mark ‘It’ will be taken to mean krypton. So, ‘It is less’ can gain a mark   
allow ‘heavier’ to mean more massive’   
allow vague statements like speed is less for 2nd mark but not in the first mark*

**2**

[7]

2.

(i) (heat supplied by glass = heat gained by cola)  
(use of *m*g *c*g *ΔT*g =*mc* cc *ΔT*c)

*1st mark for RHS or LHS of substituted equation*

0.250 × 840 × (30.0 – Tf) = 0.200 × 4190 × (Tf – 3.0) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png

*2nd mark for 8.4°C*

(210 × 30 – 210 *t*f = 838 *T*f – 838 × 3)  
*T*f = 8.4(1) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img02.pnghttp://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png

*Alternatives:*

*8°C is substituted into equation (on either side shown will get mark)http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png*

*resulting in 4620J~4190J http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png*

*or*

*8°C substituted into LHS http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png(produces ΔT = 5.5°C and hence)*

*= 8.5°C ~ 8°C http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png*

*8°C substituted into RHS http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png*

*(produces ΔT = 20°C and hence)*

*= 10°C ~ 8°C http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png*

**2**

(ii) (heat gained by ice = heat lost by glass + heat lost by cola)

*NB correct answer does not necessarily get full marks*

(heat gained by ice = *mcΔT* + *ml*)  
heat gained by ice = *m* × 4190 × 3.0 + *m* × 3.34 × 105 http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png  
(heat gained by ice = *m* × 346600)

*3rd mark is only given if the previous 2 marks are awarded*

heat lost by glass + heat lost by cola  
= 0.250 × 840 × (8.41 – 3.0) + 0.200 × 4190 × (8.41 – 3.0) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png  
(= 5670 J)

*(especially look for m × 4190 × 3.0)*

*the first two marks are given for the formation of the substituted equation not the calculated values*

*m* (=5670 / 346600) = 0.016 (kg) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png

*if 8oC is used the final answer is 0.015 kg*

or (using cola returning to its original temperature)  
(heat supplied by glass = heat gained by ice)  
(heat gained by glass = 0.250 × 840 × (30.0 – 3.0))  
heat gained by glass = 5670 (J) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png  
(heat used by ice = *mcΔT* + *ml*)  
heat used by ice = *m*(4190 × 3.0 + 3.34 × 105) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png(= *m*(346600))

*m* (=5670 / 346600) = 0.016 (kg) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS13503_files&file=img01.png

**3**

[5]

3.

(a) graph passes through given point 2.2 × 10–3 m3 at 0 °C straight  
line with positive gradient http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

(straight) line to aim or pass through –273 °C at zero volume http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

**2**

(b) (use of n = *P V/R T*)

1.00 × 105 × 2.20 × 10–3/8.31 × 273 http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

*n* = 0.0970 (moles) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

**2**

(c) (use of mean kinetic energy = 3/2 K T)

= 3/2 × 1.38 × 10–23 × 323 http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

6.69 × 10–21 (J) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png3 sfs http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

**3**

(d) total internal energy = 6.69 × 10–21 × 0.0970 × 6.02 × 1023 = 390 (J) http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MS11505_files&file=image001.png

**1**

(e) **The candidate’s writing should be legible and the spelling,  
punctuation and grammar should be sufficiently accurate for the  
meaning to be clear.**

The candidate’s answer will be assessed holistically. The answer  
will be assigned to one of three levels according to the following criteria.

**High Level (Good to excellent): 5 or 6 marks**

The information conveyed by the answer is clearly organised,  
logical and coherent, using appropriate specialist vocabulary  
correctly. The form and style of writing is appropriate to answer  
the question.

The candidate provides a comprehensive and coherent sequence  
of ideas linking the motion of molecules to the pressure they exert  
on a container. At least three of the first four points listed below must be  
given in a logical order. The description should also show awareness  
of how a balance is maintained between the increase in speed and  
shortening of the time interval between collisions with the wall to maintain  
a constant pressure.  
To be in this band, reference must be made to force being the rate of  
change of momentum or how, in detail, the volume compensates for the  
increase in temperature.

**Intermediate Level (Modest to adequate): 3 or 4 marks**

The information conveyed by the answer may be less well organised  
and not fully coherent. There is less use of specialist vocabulary, or  
specialist vocabulary may be used incorrectly. The form and style of  
writing is less appropriate.

The candidate provides a comprehensive list of ideas linking the  
motion of molecules to the pressure they exert on a container. At least  
three of the first four points listed below are given. The candidate also  
knows than the mean square speed of molecules is proportional to  
temperature. Using this knowledge, an attempt is made to explain how  
the pressure is constant.

**Low Level (Poor to limited): 1 or 2 marks**

The information conveyed by the answer is poorly organised and may  
not be relevant or coherent. There is little correct use of specialist vocabulary.  
The form and style of writing may be only partly appropriate.

The candidate attempts the question and refers to at least two of the  
points listed below.

**Incorrect, inappropriate of no response: 0 marks**

No answer or answer refers to unrelated, incorrect or inappropriate  
physics.

**Statements expected in a competent answer should include some of  
the following marking points.**

molecules are in rapid random motion/many molecules are involved

molecules change their momentum or accelerate on collision with  
the walls

reference to Newton’s 2nd law either *F* = *ma* or *F* = rate of change of  
momentum

reference to Newton’s 3rd law between molecule and wall

relate pressure to force *P* = *F/A*

mean square speed of molecules is proportional to temperature

as temperature increases so does change of momentum or change in  
velocity

compensated for by longer time between collisions as the temperature  
increases

as the volume increases the surface area increases which reduces the  
pressure

**max 6**

**[14]**

4

(a) (use of http://content.doublestruck.eu/getPicture.asp?sub=AA_PA&CT=M&org=b5a69a2fdd9c5a31b56ff3bc804be010&folder=MAW03205_files&file=image001.png*=* *Pt* gives)

0.725 × *c* × (100 – 20) **(1)** =2000 × 120 **(1)**

*c =* 41 00 **(1)** J kg–1 **(1)** (4140 J kg–1)

**4**

**QWC 2**

(b) (i) (use of *mL* = *Pt* gives) 94 × 10–3 *L* *=* 2000 × 105 **(1)***L* = 2.2 × 106 J kg–1 **(1)**

(ii) no evaporation (before water heated to boiling point)  
no heat lost (to the surroundings)  
heater 100% efficient any two **(1) (1)**

**4**

**[8]**