

Answer Key to BT1 2010 MCQ

1	B	14	A
2	C	15	B
3	B	16	D
4	C	17	B
5	B	18	C
6	A	19	D
7	A	20	B
8	C	21	D
9	D	22	C
10	D	23	D
11	B	24	D
12	C	25	A
13	A		

2010 JC1 Block Test 1 Paper 2 Structured Questions Mark Scheme

- 1 (a) (i) Nitrogen is in Period 2 and **does not have any available d-orbitals/ does not have 2d orbitals**. Thus, nitrogen **cannot expand its octet** to accommodate more than 8 electrons. Thus it is unable to form NCI_5 .

- (ii) : 0.110 nm P^{3-} : 0.212 nm

P^{3-} has more electrons than P. As such, there is **more inter-electronic repulsion** between its electrons.

The nucleus has a **weaker attraction** for the valence electrons and thus the ionic radius of P^{3-} is larger than the radius of P.

Also accept:

P^{3-} has more electrons than P and thus, there is **greater shielding effect** in P^{3-} .

The nucleus has a **weaker attraction** for the valence electrons and thus the ionic radius of P^{3-} is larger than the radius of P.

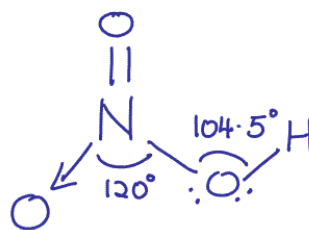
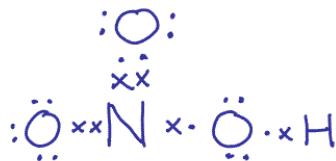
- (b) Total number of electrons: 12

Note: total 55 electrons NOT accepted.

Value of n : 2

Oxidation number of Sb: +3

2 (a)



Trigonal planar w.r.t N
Bent w.r.t O

(b) (i) N_2H_4 on an average has 2 H-bonds per molecule while NH_3 has an average of 1 H-bond per molecule. More energy is required to overcome the **more extensive hydrogen bonding in N_2H_4** than in NH_3 . Hence, higher b.p. for N_2H_4 than NH_3 .

(ii) Hydrogen bonds in H_2O_2 is stronger than those in N_2H_4 as **O is more electronegative than N**. There is thus a stronger attraction between the more δ^+ H in H_2O_2 and the lone pair of electrons on O atom. Hence, more **energy** is required to overcome the stronger hydrogen bonds in H_2O_2 than in N_2H_4 . Thus, H_2O_2 has a higher b.p. than N_2H_4 .

(c) (i) $P_T V_T = P_A V_A + P_B V_B$
 $P_T(590) = (200)(500) + (300)(90)$
 $P_T = \mathbf{215 \text{ kPa}}$

(ii) The pressure will drop when temperature drop from 80°C to 30°C . At low temperature of 30°C , the gas particles have lower average kinetic energy and thus have **fewer and/or weaker** collisions with the vessel wall, resulting in the decreased pressure.

(iii) At 0°C , gas **B** becomes a liquid. Only gas **A** exerts the pressure.

$$\begin{aligned} \eta_f &= \eta_A \\ &= \frac{(200 \times 10^3)(500 \times 10^{-6})}{(8.31)(353)} \\ &= 0.0341 \text{ mol} \end{aligned}$$

$$\begin{aligned} P_F &= \frac{\eta_f RT}{V_f} \\ &= \frac{(0.0341)(8.31)(273)}{590 \times 10^{-6}} \\ &= \mathbf{131 \text{ kPa}} \end{aligned}$$

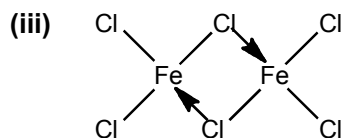
(d) (i) **X** : HCl ; **Y** : H_2O

(ii) H_2O have strong hydrogen bonding between molecules while HCl have pd-pd interactions between molecules. H_2O , with more significant intermolecular forces compared to HCl , should therefore deviate more from ideal than HCl .

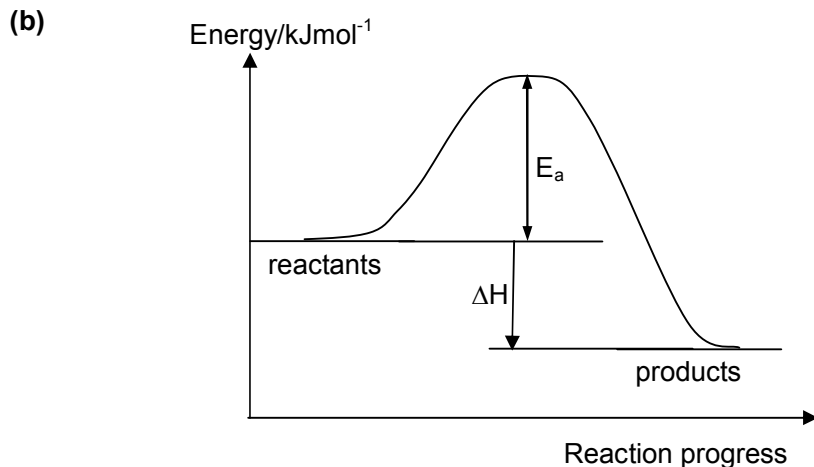
Also accept: HCl being a bigger molecule compared to H_2O , will have more significant volume compared to H_2O . Hence, *at the higher pressure region, HCl should deviate more from ideal than H_2O .*

- 3 (a) (i) neutrons are **uncharged and** are not repelled (*both points must be present*) by protons in the nuclei of atoms
- (ii) No change as new isotope formed has the same electronic configuration/ same number of electrons as the original element
- (iii) ^{12}C , ^{13}C and ^{14}C are isotopes and the valence electrons experience the **same effective nuclear charge** (this is the key word) (or same nuclear charge and shielding effect) and thus their first ionization energies would be almost the same.
 Note: reject "same number of protons and electrons"

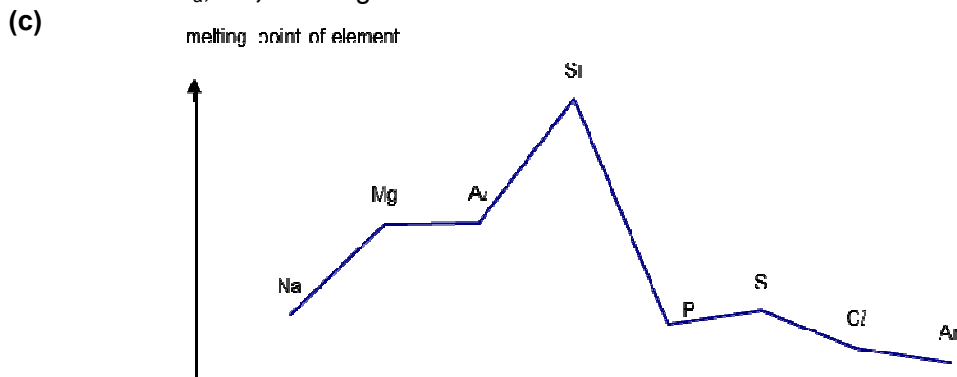
- (b) (i) Using $pV = nRT$, Apparent Mr = 244
 Note: 1 m for number of moles, 1 m for Mr
- (ii) Let percentage of dimer be x: $324.6x + 162.3(1-x) = 244$
 Hence percentage of dimer = 50.3 %



- 4 (a) (i) $\Delta S > 0$ as there is an increase in the no. of gaseous molecules (system has more ways in which it can distribute energy amongst the gaseous molecules).
- (ii) Since $\Delta H < 0$ and $\Delta S > 0$, $\Delta G = \Delta H - T\Delta S$, $\Delta G < 0$ at all temperatures. Reaction is feasible at all temperatures.



Correct shape of curve with reactants higher energy level than products ; E_a , ΔH , labelling of axes

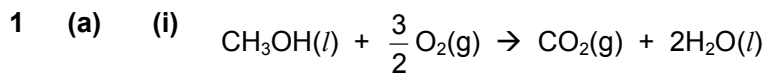


showing correct trend in graph:

- Increasing m.p. from Na to Si
- Sharp decrease in m.p. from Si to P_4
- M.p. of $S_8 > P_4 > Cl_2 > Ar$

- Na, Mg and Al have giant metallic structures which contains strong electrostatic attraction between the cations and sea of delocalised electrons [0.5]. Melting point increases from Na to Al, corresponding to the increasing number of valence electrons per atom.
- Si has a very high melting point due to its giant covalent structure.
- P_4 , S_8 , Cl_2 and Ar have generally low melting point as P_4 , S_8 , Cl_2 are simple covalent molecules and Ar exist as atoms held by weak dispersion forces.
- Dispersion force strength decreases from $S_8 > P_4 > Cl_2 > Ar$ due to decreasing no. of electrons, hence less energy required to overcome the weaker dispersion force. Thus, melting point decreases in the same order.

2010 JC1 Block Test 1 Paper 2 Free Response Questions Mark Scheme



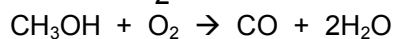
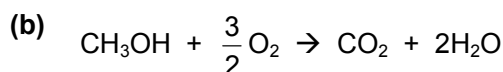
(ii) $\Delta H_c^\circ(\text{methanol}) = -393 + 2(-286) - (-239)$
 $= \underline{-726 \text{ kJ mol}^{-1}}$

(iii) Energy required to break bonds = $3(410) + (360) + (460) + \frac{3}{2}(496)$
 $= +2794 \text{ kJ mol}^{-1}$
 Energy released when forming bonds = $2(740) + 4(460)$
 $= -3320 \text{ kJ mol}^{-1}$

$\Delta H_c = +2794 + (-3320) = \underline{-526 \text{ kJ mol}^{-1}}$

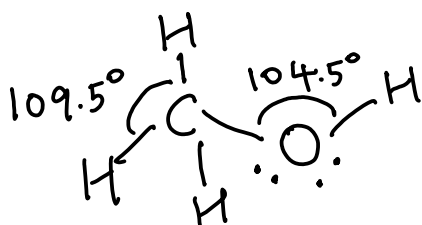
(iv) • **All the reactants and products** in (iii) are assumed to be **gaseous**, when under standard conditions both methanol and water are liquids.

• Bond energy values in the Data Booklet are **average values**. (since an actual B.E. depends upon the molecular environment in which the bond exists).

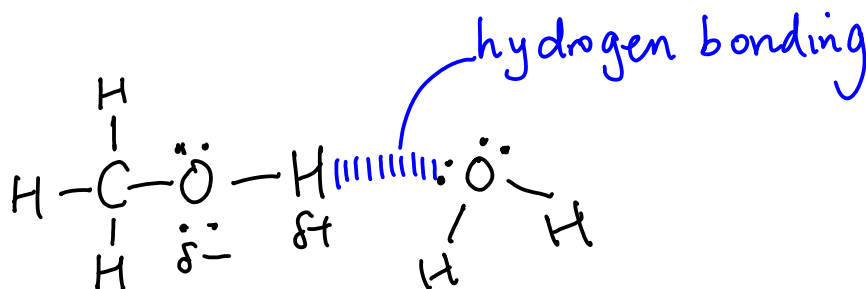


Volume of O_2 consumed = $\frac{3}{2}(0.98)(18) + 0.02(18)$
 $= \underline{26.8 \text{ cm}^3}$

(c) (i)



(ii)



(d) (i) Oxidation no. in methanol = -2
 Oxidation no. in carbon monoxide = +2

(ii) CO, CH₃OH, CH₃CO₂H

CH₃OH and CH₃CO₂H deviate more than CO, because CH₃OH and CH₃CO₂H have **hydrogen bonding** between its molecules which is more significant than the **permanent dipole-permanent dipole interactions** between CO molecules.

CH₃CO₂H deviates more than CH₃OH because CH₃CO₂H is a **larger molecule**, thus it has a **more significant volume compared to the volume of the container**.

OR

CH₃CO₂H deviates more than CH₃OH because CH₃CO₂H is a **larger molecule with more electrons**, thus it has **more significant dispersion forces / VDW forces**.

OR

CH₃CO₂H deviates more than CH₃OH because CH₃CO₂H has **more extensive hydrogen bonding** between its molecules.

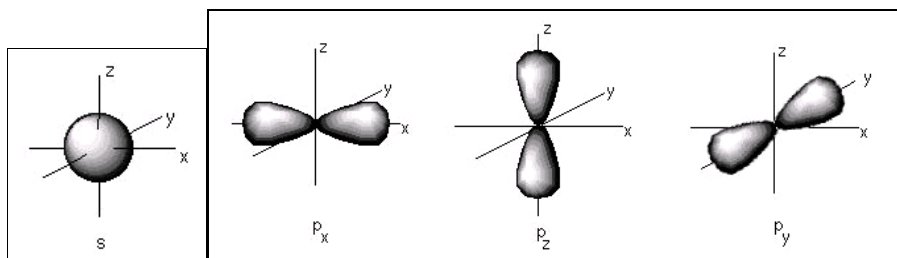
(iii) $\Delta G = \Delta H - T\Delta S = 0$

$$T\left(\frac{-155}{1000}\right) = -121$$

$$T = \mathbf{781\ K}$$

2 (a) (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

(ii)



(For p orbitals, drawing one is enough / all three on the same axes)

(b) (i) MnO_2

(ii) **B** = $KMnO_4$, Disproportionation reaction / redox reaction

(iii) $3 MnO_4^{2-} + 2 H_2O \rightarrow 2 MnO_4^- + MnO_2 + 4OH^-$

(iv) No. of moles of Fe^{2+} reacted = 1.12×10^{-3}
No. of moles of MnO_4^- present (25.0 cm^3) = 2.24×10^{-4}
No. of moles of MnO_4^- present (500 cm^3) = 4.48×10^{-3}
 $3 MnO_4^{2-} + 2 H_2O \rightarrow 2 MnO_4^- + MnO_2 + 4OH^-$
No. of moles of MnO_4^{2-} = $(4.48 \times 10^{-3} / 2) \times 3 = 6.72 \times 10^{-3}$
Mass of K_2MnO_4 = $6.72 \times 10^{-3} \times 197.1 = 1.32 \text{ g}$
% purity = $(1.32/2.00) \times 100\% = 66.0 \%$

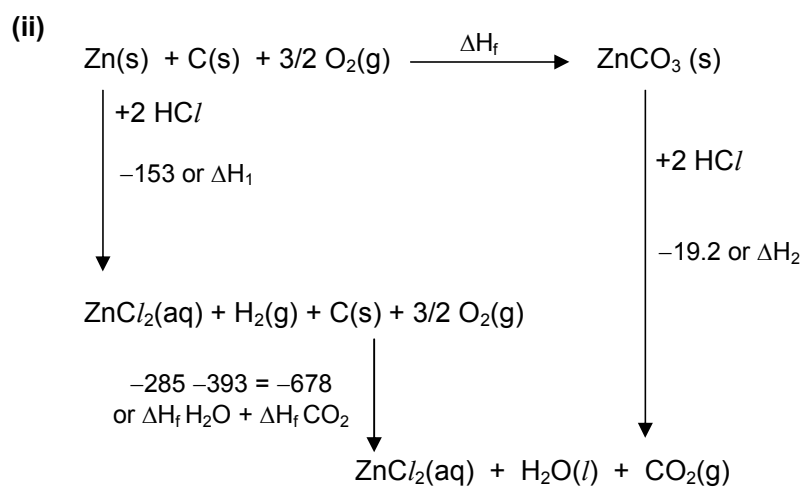
(c) (i) No. of moles of Zn(s) used = $0.10/65.4 = 1.53 \times 10^{-3}$
No. of moles of HCl used = $(10.0 \times 1.00)/1000 = 0.0100$
Zn(s) is limiting reagent.

Average temp rise = 5.6 K

$$\Delta H_1 = - [(10.0 \times 4.18 \times 5.6)/1000] / 1.53 \times 10^{-3} = -153 \text{ kJ mol}^{-1}$$

No. of moles of $ZnCO_3$ used = $0.80/125.4 = 6.38 \times 10^{-3}$
No. of moles of HCl used = $(10.0 \times 1.00)/1000 = 0.0100$
HCl is limiting reagent

$$\Delta H_2 = - [(10.0 \times 4.18 \times 4.6)/1000] / 0.0100 = -19.2 \text{ kJ mol}^{-1}$$



By Hess' Law:

$$\Delta H_f + (-19.2) = -153 + (-678)$$

$$\Delta H_f = -812 \text{ kJ mol}^{-1}$$

- 3 (a) Mg is a good conductor of electricity as it contains mobile electrons which act as charge carrier.

Mg is a good conductor of heat as the mobile electrons enable the transfer of heat energy from the higher temperature region to the lower temperature region.

Mg is malleable or ductile as the cations in the solid structure can slide past each other through the sea of delocalized electrons.

Mg is shiny as light that falls onto the metal surface can excite the electrons into unfilled orbitals. When the electrons return to lower energy states, energy is emitted as light.

- (b) (i) Amount of $\text{CO}_2 = \frac{48}{24000} = 2.00 \times 10^{-3} \text{ mol}$
- (ii) Amount of acid left unreacted in 250 cm^3
 $= \frac{40.00}{1000} \times 0.0150 \times 10 = 6.00 \times 10^{-3} \text{ mol}$
- \therefore Amount of acid that reacts with the mineral
 $= \left(\frac{100}{1000} \times 0.100 \right) - 6.00 \times 10^{-3} = 4.00 \times 10^{-3} \text{ mol}$

- (iii) Amount of Ba present in the mineral
 $= \frac{0.0932}{233.1} \times \frac{250}{100} = 1.00 \times 10^{-3} \text{ mol}$

Amount of Mg present in the mineral

$$= \frac{4.00 \times 10^{-3}}{2} - 1.00 \times 10^{-3} = 1.00 \times 10^{-3} \text{ mol}$$

$x : y : z$

$$= 1.00 \times 10^{-3} : 1.00 \times 10^{-3} : 2.00 \times 10^{-3}$$

$$= 1 : 1 : 2$$

$$\therefore x = 1, y = 1, z = 2$$

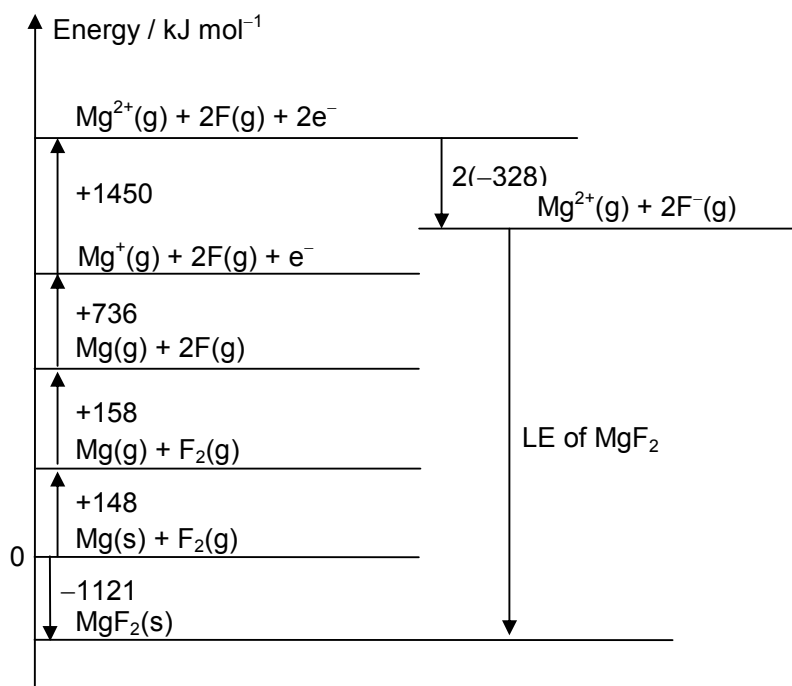
[-1m overall if correct number of significant figures are not given]

- (c) MgC_2 has a giant ionic lattice structure with electrostatic forces of attraction between Mg^{2+} and C_2^- .

It dissociates in water to give Mg^{2+} and C_2^- ions which can form ion-dipole interaction with water.

- (d) (i) Energy released when 1 mole of solid MgF_2 is formed from its constituent gaseous ions (Mg^{2+} and F^-).

(ii)



$$+148 + 158 + 736 + 1450 + 2(-328) + \text{LE} = -1121$$
$$\therefore \text{LE of MgF}_2 = -2957 \text{ kJ mol}^{-1}$$

(iii)

$$\text{LE} \propto \frac{q^+ \times q^-}{r^+ + r^-}$$

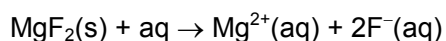
Magnitude of lattice energy of MgCl_2 is lower than MgF_2 as Cl^- has a larger ionic radius than F^- .

Magnitude of lattice energy of MgO is higher than MgF_2 as O^{2-} has higher ionic charge than F^- .

(iv) ΔH_{soln} of $\text{MgF}_2 = -467 + 2(-335) - (-1121) = -16 \text{ kJ mol}^{-1}$

(v) $\Delta G_{\text{soln}} = \Delta H_{\text{soln}} - T\Delta S_{\text{soln}}$

Since MgF_2 is insoluble in water, $\Delta G_{\text{soln}} > 0$. Since $\Delta H_{\text{soln}} < 0$, ΔS_{soln} must be negative.



ΔS_{soln} is negative as the decrease in entropy due to ordering of water molecules is greater than the increase in entropy due to disruption of the regular arrangement of ions in the solid structure.