C1 HCI Chemistry Block Test ANSWER

Paper 1: MCQ

1	В	11	В
2	D	12	Α
3	Α	13	С
4	В	14	Α
5	В	15	С
6	D	16	D
7	В	17	С
8	D	18	Α
9	С	19	D
10	D	20	Α

Paper 2:

1 (a)
$$Mg(NO_2)_2 \cdot xH_2O \rightarrow Mg(NO_2)_2 + xH_2O$$

mass of water = 2.00 - 1.24 = 0.76 g

 $n(H_2O) = 0.76 / 18.0 = 0.04222 \text{ mol}$

 $n(Mg(NO_2)_2) = 1.24 / 116.3 = 0.01066 mol$

x = 0.04222 / 0.01066 = 3.96 = 4 (whole no.)

(b) The number of water of crystallization is higher than in the given information.

The likely reason for the discrepancy is that on heating, the <u>magnesium nitrite</u> <u>decomposed</u>.

Therefore the mass loss is higher than the actual value and this results in a higher value of x.

(c) (i)
$$5NO_2^- + 2MnO_4^- + 6H^+ \rightarrow 5NO_3^- + 2Mn^{2+} + 3H_2O$$

- (ii) Using a <u>fixed mass</u> of magnesium nitrite, dissolve in <u>deionised water</u> in a <u>volumetric/standard/graduated flask</u>
- (iii) The solution in the flask turns from pink to colourless at the endpoint.
- (iv) Repeat the titration until <u>two titre values</u> within ± 0.10 cm³ of each other are obtained.
- **2** (a) (i) 2σ and 2π
 - (ii) $C = N \rightarrow H \quad or \quad C = N \rightarrow H \quad or \quad C = N \rightarrow H$

(b) (i) $CN^- + H^+ \rightarrow HCN$

$$\eta(\text{HCN}) = \eta(\text{NaCN}) = \frac{1.0}{23.0 + 12.0 + 14.0} = \frac{1.0}{49.0} = 0.02041 \text{ mol}$$

Mass of HCN formed = 0.02041 x 27.0 = 0.551 g

(ii) [HCN] = $\frac{0.551 \times 1000}{75 \times 1000}$ mg dm⁻³ = 7.35 x 10⁻³ ppm

The concentration of HCN has not exceeded the exposure limit.

- (c) (i) ∆S is <u>positive</u> since the number of moles of <u>gaseous</u> products is more than that of reactants (or there is an increase in the number of <u>gaseous</u> molecules). Hence, there are <u>more ways in which the particles and their energies can be distributed</u> in a larger volume.
 - (ii) $\eta(CH_4)$ left = 0.5 0.25 = 0.25 mol $\eta(HCN)$ formed = 0.25 mol $\eta(H_2)$ formed = 3 x 0.25 = 0.75 mol

Total no. of moles of gases = 1.25 mol

$$p = \frac{1.25 \times 8.31 \times (273 + 100)}{(5+5) \times 10^{-3}}$$

= 387000 Pa = 387 kPa



- 1. The ions (N^{3-} to $Al^{\beta+}$) are <u>isoelectronic</u>.
- 2. Nuclear charge increases (while shielding effect remains constant).
- 3. Effective nuclear charge increases Or The electrons are more strongly attracted to the nucleus and hence size of ions decreases.

3 (a) (i) trigonal planar

(d)

- (ii) sp²
- (iii) \propto)



- (b) (i) Bond energy refers to the <u>average</u> energy required to break 1 mole of a <u>covalent</u> <u>bond</u> in the gaseous atoms.
 - (ii) $\Delta H_r = \Sigma B.E.$ (bonds broken) $\Sigma B.E.$ (bonds formed) = [(C=C) x 1 + (H-H) x 1] - { [(C-H) x 2] + C-C} = [(610) x 1 + (436) x 1] - { [(410) x 2] +350 } = 1046 - 820 - 350 = - 124 kJ mol⁻¹
- (c) (i) Vitamin C can form hydrogen bonding with water molecules in urine.
 - (ii) Dehydroascorbic acid is less soluble due to less extensive hydrogen bonding (or fewer –OH groups available for hydrogen bonding or fewer H atoms that can form hydrogen bonding)
- 4 (a) (i)



(ii) SO₂ has two bonding groups of electrons and one lone pair, hence its shape is bent.

As lone pair-bond pair repulsion is greater than bond pair-bond pair repulsion, the angle should be 118° . (Accept any angle between 109.5° and 120° .)

(b) (i)
$$I_2 + SO_2 + 2H_2O \rightarrow 2HI + H_2SO_4$$

(ii) No. of moles of $H_2 = \frac{500}{24000} = 0.0208 \text{ mol}$

No. of moles of HI required = $0.0208 \times 2 = 0.0416$ mol

No. of moles of SO_2 required = 0.0208 mol

(c) (i)
$$2HI(g) \longrightarrow I_2(s) + H_2(g)$$

+62.4 \downarrow
 $I_2(g)$
+151 \downarrow
2I (g) + 2 H (g)

 $\Delta H_{rxn} = 2(299) - (+151) - (+62.4) - (436) = -51.4 \text{ kJ mol}^{-1}$

(ii) $\Delta G = \Delta H - T \Delta S$

At 400K, $\Delta G = -51.4 - 400 (-166 \times 10^{-3})$

 $\Delta G = + 15.0 \text{ kJ mol}^{-1}$ The reaction is not feasible at 400K.

Paper 3

Question 1

(a) CaF_2 has a giant <u>ionic</u> structure, with strong ionic bonding (strong electrostatic forces of attraction b/w cations and anions).

When force applied, ions of like charges are brought next to each other and the repulsive forces crack the compound.

(b)(i) Energy/ kJ mol⁻¹



E.A. of F = $(-1220 - 177 - 590 - 1150 - 158 + 2613) / 2 = -341 \text{ kJ mol}^{-1}$

(ii) From Data booklet, $r^+(Ca^{2+}) = 0.099$ nm, $r^+(Mg^{2+}) = 0.065$ nm

L.E. $\propto \frac{(q+)(q-)}{r^++r^-}$ $r^+(Ca^{2+}) > r^+(Mg^{2+})$ Hence, magnitude of L.E. of MgF₂ is greater than magnitude of L.E. of CaF₂.

(c) X has a <u>net dipole moment (or is polar)</u> and <u>permanent dipole- permanent dipole interactions</u> exist.
Y has net <u>zero dipole moment (or is non-polar)</u> and <u>dispersion forces</u> exist between molecules of Y

<u>More energy</u> is required to overcome the stronger permanent dipole- permanent dipole interactions, hence \mathbf{Y} has higher boiling point.

- (d) H-F bond is highly polarized (large difference in electronegativity between H and F) while P-H bond is non-polar.
 - Partial ionic character in H-F bond leads to increase in strength.
- (e)(i) HF forms <u>hydrogen bonding</u> with ethanol molecules. NaF dissolves in water to form <u>ion-dipole interaction</u> with water molecules.



Question 2

- (a)(i) $O^+(g) \to O^{2+}(g) + e$ (a)(ii) $\Delta H = +3390 - 1310$
 - = +2080 kJ mol⁻¹
- (a)(iii) There is a big jump in ionization energy from the 7^{th} IE to the 8^{th} IE.

Therefore the 8^{th} electron to be removed is in an inner quantum shell, so **A** has 7 valence electrons.

(a)(iv) The first IE of **A** is smaller than oxygen. Therefore it cannot be fluorine because fluorine is in the same period and has a higher effective nuclear charge, so its first IE would be greater.

or

A should be chlorine because Cl has a larger atomic radius. The electron to be removed is further from the nucleus and not attracted as strongly, therefore less energy is required to remove it and the first IE is lower compared to oxygen.

(b)(i) pV=nRT

pV=(m/Mr) RT

Mr = (RT/P) (m/V)

which is in the form

Molar mass = y x density i.e. y = RT/P

At stp, y = 8.31 x 273 / 101300

= 2.24 x 10⁻² (shown)

The second mark is awarded if student recognizes y as the molar volume at stp and converts 22.4 dm³ to 2.24 x 10^{-2} m³.

(b)(ii) Apparent molar mass of mixture = $2.24 \times 10^{-2} \times 1.83 \times 10^{3}$ = 41.0 g mol^{-1}

> The shielding gas is **E**. The apparent molar mass of mixture is higher than that of argon ($M_r = 39.9$), therefore the second gas must have M_r higher than argon, therefore it is carbon dioxide ($M_r = 44.0$).

(b)(iii) Let the number of moles of argon be x.

39.9x + 44.0(1-x) = 41.0x = 0.732

- (b)(iv) Shielding gas E shows the most deviation from ideal gas behaviour. Out of the 4 gases H₂, He, O₂ and CO₂, the <u>CO₂ has the largest electron cloud</u>, so the <u>strength of the dispersion forces</u> between its molecules (and also between its molecules and Ar atoms) should be the <u>strongest</u>. (accept volume is more significant as electron cloud size is larger)
- (c)(i) Number of moles of Sn^{2+} in 25.0 cm³ of solution **G** = 0.0135 x 0.0200 x 2.5 = 6.75 x 10⁻⁴

or

(c)(v) <u>Fe(II) will be further oxidized</u> to Fe(III) by $KMnO_4$ in addition to the oxidation of Sn(II) to Sn(IV). Therefore the titre value will be <u>higher than expected</u>.

Question 3

- (a) (i) MgCO₃; Mg²⁺ has a <u>smaller ionic radius</u> as compared to Ba²⁺ and hence it has a higher charge density, hence MgCO₃ has the lower decomposition temperature. The compounds present at 700 °C are: Na₂CO₃, BaCO₃ and MgO.
 - (ii) $xNa_2CO_3 \cdot yMgCO_3 \cdot zBaCO_3 (s) \rightarrow xNa_2CO_3(s) + yMgO(s) + zBaO(s) + (y + z) CO_2(g)$
 - (iii) Mass of CO_2 loss after TGA = 5.00 3.55 = 1.45 g

Amount of Ba present in *somaba* = (0.283/233.1) x 10 = 0.01214 mol

Amount of Mg present in somaba = (1.45/44.0) - 0.01214 = 0.02081 mol

Mass of Na₂CO₃ in *somaba* = $5.00 - (0.01214 \times 197) - (0.02081 \times 84.3)$ = 0.854 g

% mass of Na₂CO₃ in somaba = 0.854/ 5.00 x 100% = 17.1%

- (b) (i) The standard enthalpy change of neutralization is the heat evolved when 1 mole of water is formed in the neutralisation reaction between an acid and a base, at 298 K and 1 atm.
 - (ii) n(HF) = n(NaOH) $n(H_2O) = 30/1000 \times 1.00 = 0.030 \text{ mol}$ $\Delta T = 30.5 - 25.0 = 5.5 \,^{\circ}C$

 $\Delta H_{\text{neutralisation}} = - (90 \text{ x } 4.2 \text{ x } 5.5) / 0.030$ = - 69.3 kJ mol⁻¹

(iii) The value obtained in (b)(ii) is more exothermic than the standard enthalpy change of neutralisation between HCl (aq) and NaOH (aq), because the <u>enthalpy change of hydration</u> <u>of fluoride ion is much more exothermic</u> than chloride ion and the heat released is more than sufficient to drive the dissociation of molecular HF.



The electrical conductivity increases from Na to Mg to A*l* due to the increase in the contributions of valence electrons to the sea of delocalised electrons.

Si has lower electrical conductivity than the three metals as it is a semiconductor.

The four non-metallic elements exist as simple discrete molecules (except for argon, which is monatomic) and they are non-conductors as they do not have free mobile electrons and ions in their crystal structures.

- (d) (i) A positive entropy change is achieved due to the broadening of the Boltzmann energy distribution (or increase in average kinetic energy) and as a result, there are more ways of arranging the particles and their energies at the higher temperature.
 - (ii) For process I, $\Delta S = 0$ as the accessible volume per particle does not change (hence SMI does not change).

For process II, $\Delta S < 0$ as the accessible volume per particle decreases (hence SMI decreases).