Suggested solutions to 2009 RIJC H2 Chemistry Prelim Paper 2

1(a)(i) 1s²2s²2p⁵

(a)(ii)



Can also accept p_x and p_y orbital Zero mark if all three orbitals are drawn

(b)(i) Include IE data

O: 1s²2s²2p⁴

The 1st IE increases from O to F as the **number of protons increases** in F but the **shielding effect** remains **effectively constant**.

(b)(ii) O⁺: 1s²2s²2p³

F⁺: 1s²2s²2p⁴

The 2nd IE decreases from O to F due to inter-electronic repulsion between the 2p electrons in F

(c)(i)
$$2H^+(aq) + Mg(OH)_2(s) \longrightarrow Mg^{2+}(aq) + 2H_2O(l)$$

(c)(ii)
$$Mg^{2+}(aq) + 2F^{-}(aq) \longrightarrow MgF_{2}(s)$$

The Mg^{2+} released from the acid–base reaction in the stomach reacts with the F⁻ present to form a precipitate of MgF_2 which is **insoluble** and is thus **not easily absorbed** by the body. Precipitation occurs when

(C)(III) Precipitation occurs wher
$$(A_{2}^{2+1})^{-12}$$

$$[Mg^{2+}][(\frac{1 \times 10^{-3}}{19.0})/1.0]^{2} > 5.16 \times 10^{-11}$$
$$[Mg^{2+}] > 0.0186 \text{ mol } dm^{-3}$$

(vol. of milk of magnesia needed)(1.40) = (0.0186)(vol. of liquid in stomach) i.e. vol. of milk of magnesia needed = 0.0133 dm³ (i.e. 13.3 cm³)

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Data 142 mg of F⁻ in 1 tube of toothpaste Stomach when filled with food about 1 L i.e. 1 dm³ Milk of Magnesia, 8 g Mg(OH)₂ in 100 mL is (8 / 58.3) \div 0.1 = 1.37 mol dm⁻³ **2(a)** An ideal gas is one which experiences negligible intermolecular forces of attraction and has negligible volume.

OR obeys the ideal gas equation (pV = nRT) perfectly.

- (b)(i) ρV $[\frac{1}{2}]$ correct shape [$\frac{1}{2}$] CO₂ above NH₃ carbon dioxide ammonia ideal gas
- (b)(ii) At lower pressures, NH₃(g) deviates from ideal behaviour to a **greater** extent since it experiences **stronger** Intermolecular forces of interaction (hydrogen bonding) as compared to CO₂ (instantaneous dipole–induced dipole interaction).

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- (c)(i) Lightning OR forest fires OR volcanoes OR *other sensible answers*. (but NOT human acts e.g. burning of fuels, combustion engines etc.)
- (ii) High temperatures are needed to overcome the strong N=N.

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(d)
$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

(e) Let the change in [N₂] be x mol dm⁻³ Eqm concentrations of N₂, O₂ and NO are 1-x, 1-x and 2x mol dm⁻³ respectively. $K_c = \frac{[NO]^2}{[N_2][O_2]}$ $6.2 \times 10^{-14} = \frac{[NO]^2}{(1-x)(1-x)}$ [NO]=2.49×10⁻⁷ mol dm⁻³ (assuming x << 1)

(f)(i) No change

since there are equal numbers of gaseous molecules on either side of the equation.

(Note: a change in volume does not affect such a gaseous system.)

- (ii) Position of equilibrium shifts to the right since there is an increase in concentration of N₂.
 By Le Chatelier's Principle, the system will respond by favouring the forward reaction and hence the position shifts to the right.
- **2(g)** The system can be treated as the following:

	N ₂	+ O ₂	2NO
initial conc. / mol dm ⁻³	(1.0 + 2.0) / 1.5	1.0 / 1.5	-
	= 2.0	= 0.666	
eqm conc. / mol dm ⁻³	2.0 – x	0.666 – x	2x

$$K_{c} = \frac{[NO]^{2}}{[N_{2}][O_{2}]}$$
$$6.2 \times 10^{-14} = \frac{[NO]^{2}}{(2.0 - x)(0.666)}$$

[NO]=2.873×10⁻⁷ mol dm⁻³

 $p_{NO}V=nRT$ $p_{NO}=cRT$ $=(2.873 \times 10^{-7} \times 10^{-3})(8.31)(2273)$ $=5.43 \times 10^{-6} Pa$

3(a)(i)
$$CaCO_3$$

 $CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$

(ii) Mass of S in coal = $1 \times 10^9 \times \frac{2.5}{100} = 2.5 \times 10^7 \text{kg} = 2.5 \times 10^{10} \text{g}$ Amt of S = $2.5 \times 10^{10} \div 32.1 = 7.788 \times 10^8 \text{ mol}$ Amt of CaCO₃ = Amt of S = $7.788 \times 10^8 \text{ mol}$ Mass of CaCO₃ = $7.788 \times 10^8 \times 100.1 = 7.80 \times 10^{10} \text{ g}$

-x)

- (b) Solution F is calcium chloride solution which is effectively neutral. For BeCl₂, it becomes the aqua complex, $[Be(H_2O)_4]Cl_2$ upon contact with water. The small, highly polarising Be²⁺ weakens the O–H bonds of the water molecules in its surrounding sphere of coordination and results in the release of H⁺ (or H₃O⁺) ions in solution, thus giving rise to an acidic solution. BeCl₂(s) + 4H₂O(l) \rightarrow [Be(H₂O)₄]²⁺(aq) + 2Cl⁻(aq) [Be(H₂O)₄]²⁺(aq) + H₂O(l) \longrightarrow [Be(OH)(H₂O)₃]⁺(aq) + H₃O⁺(aq)
- (c)(i) $CaCO_3 \rightarrow CaO + CO_2$



(c)(iii) From Data Booklet

ion	Mg ²⁺	Ca ²⁺
Ionic radius	0.065	0.099

The thermal stability depends on the charge density of the cation. The greater the charge density, the thermally less stable the carbonate.

Since charge density and hence polarsing power of Mg^{2+} is higher than that of Ca^{2+} , the distortion of the electron cloud of the carbonate anion, thus weakening effect of the carbon–oxygen bonds in the magnesium carbonate occurs to a greater extent. Hence $MgCO_3$ is more unstable than $CaCO_3$ and should decompose to MgO and CO_2 at a faster rate

(since its decomposition temperature is lower than that of CaCO₃.)

The mass of MgO obtained is 0.478 g, lower than x (i.e. 0.560 g)

- 4(a) Structural/positional isomerism
- (b) Geometric isomerism





trans

(c) M_r of eugenol = 164 M_r of vanillin = 152 Amt of eugenol = $16.4 \div 164 = 0.100$ mol The theoretical yield = 15.2 g Percentage yield = $13.0/15.2 \times 100 \% = 85.5 \%$

(d) Reaction with aqueous NaOH. Acid-base reaction

CH₂CHCH₂

[Other reagents include Na(s), Br₂ (aq) and acid chlorides.]

(e) Add 2,4-DNPH to each compound. Vanillin will give an orange ppt. Or add Tollens' reagent to each compound and warm [1m for the chemical test] Vanillin will give silver mirror. [Use cold alkaline KMnO₄ or acidified K₂Cr₂O₇, heat]

[1m for observation]

OCH₃ (f)

Compound B

Reasons why the yield may be low:

- 1. the cyclic ester has ring strain OR
- 2. phenol is a weaker nucleophile than its phenoxide.



- (a)(ii) At temperatures above 60° C, there is sufficient heat energy to break the hydrogen bonds maintaining the α -helix structure. This causes the α -helix structure to lose its helical shape to become a random coil.
- (a)(iii) extreme acidic pH
- (b) Primary structure of gastrin: Glu-Gly-Pro-Gly-Trp-Leu-Glu-Glu-Glu-Glu-Ala-Ala-Tyr-Trp-Met-Asp-Phe
- (c) Haemoglobin is a transport protein with **quaternary structure**. It consists of **four polypeptide chains/subunits** (specifically, two α -subunits and two β -subunits) combined together to form a globular protein. There is considerable amount of **R-group interactions** between an α -subunit and the neighbouring β -subunit. Each subunit has a **haem group** bonded to it. The iron(II) in the haem group can bind to oxygen.
- (d) Any three of the following:

Type of interaction	Diagram illustrating the type of interaction
Disulfide bridge/linkage	backbone of
	ĊH ₂ polypeptide
	│ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │ │
	disulphide ——> S
	bridge /
	S /
	CH ₂

