

# **MARKSCHEME**

**May 2000**

**CHEMISTRY**

**Higher Level**

**Paper 2**

SECTION A

1. (a) (i) Endothermic/heat absorbed/energy absorbed / increase in enthalpy / needs (a lot of) energy [1]
- (ii)  $K_c$  is decreased / OWTTE. [1]  
 Since heat is removed / since equilibrium moves to left / reverse reaction favoured. [1]
- (iii) 
$$\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$$

$$(1.6-x) \quad (1.6-x) \quad 2x$$
 [1]
- $$K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$$
- [1]
- $[\text{NO}] = 0.065 \text{ mol dm}^{-3}$  [1]  
 (If candidate uses 1.6 instead of  $(1.6-x)$ , which gives an answer of 0.066, award [2] unless it is specifically stated that an approximation has been made or  $1.6 \gg x$ .)
- (b) (i)  $\text{O}_3$ : 1st order plus reasonable attempt to justify (e.g. double  $[\text{O}_3]$  doubles rate). [1]  
 $\text{NO}$ : 1st order plus reasonable attempt to justify (e.g. triple  $[\text{O}_3]$  and triple  $[\text{NO}]$ , rate is  $\times 9$ ). [1]  
 (Two correct orders but no reasoning, award [1].)
- Rate =  $k[\text{O}_3][\text{NO}]$  (accept rate expression consistent with stated orders – ECF principle) [1]
- (ii)  $0.66 \times 10^{-4} = k \times 3 \times 10^{-6} \times 10^{-6}$   
 $k = 2.2 \times 10^7$  [1]  $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  [1] [2]  
 (Apply error carried forward (ECF) from rate expression in (i). U-1 may be applied.)
- (iii) Rate (experiment 4) =  $2.2 \times 10^7 \times 4.5 \times 10^{-6} \times 7.2 \times 10^{-6} = 7.13 \times 10^{-4}$  [1]  
**OR** Rate (experiment 4) = Rate (experiment 3)  $\times \frac{3}{2} \times \frac{8}{10} = 7.13 \times 10^{-4}$   
 (Apply ECF from rate expression in (i), must be experiment 4, units not required.)
2. (a)  $\text{C}_3\text{H}_8$  has higher boiling point; [1]  
 since it has greater  $M_r$  / greater number of electrons / greater number of carbons; [1]  
 so greater intermolecular forces / more energy needed. [1]
- (b)  $\text{CH}_3\text{CH}_2\text{OH}$  has higher boiling point; [1]  
**hydrogen bonding** between molecules; [1]  
 so more energy needed to separate molecules / so greater intermolecular forces. [1]

3. (a) Acidic because H<sup>+</sup> donor and basic because H<sup>+</sup> acceptor. [1]  
 Suitable equation OWTTE involving water [1]

(b) O<sup>2-</sup>/oxide ion (allow O<sup>-2</sup>) [1]

(c) Electrical conductivity **OR** pH meter (or indicator paper) [1]  
 Strong: good conductor **OR** Strong: low pH [1]  
 Weak: poor conductor **OR** Weak: high pH [1]  
 (Allow full range indicator, do not allow litmus, use judgement on other methods.)

(d) Ratio of moles = 60×0.2:40×0.15 [1]  
 (acid:alkali) = 2 : 1

Acid is in excess and reacts to form salt. [1]  
 Moles acid : moles salt = 1:1

$$K_a = \frac{[H^+][A^-]}{[HA]} / [H^+] = K_a \frac{[HA]}{[A^-]} \quad [1]$$

pH = 4.86 [1]

(Weak acid calculation based on excess acid giving a pH of 3.04 [3 max];  
 Weak acid calculation based on total acid giving a pH of 2.89 [2 max];  
 Solution based on ½ neutralisation worth [4];  
 Working must be shown.)

4. (a) Reducing agent donates/loses electrons / OWTTE. [1]
- (b) Current flow: Al → Ni [1]  
 Al<sup>⊖</sup>, Ni<sup>⊕</sup> (both) [1]
- (c)  $2\text{Al} + 3\text{Ni}^{2+} \rightarrow 3\text{Ni} + 2\text{Al}^{3+}$  [2]

*(Award [1] for correct species on correct sides of equation and [1] for correct coefficients, even if equation reversed.)*

$$E^{\ominus} = +1.43 \text{ V} \quad [2]$$

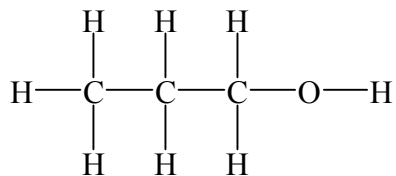
*(Award [1] each for sign and value. Allow –1.43 V if equation reversed – ECF principle. If signs not appropriate but value correct, award [1]. If  $E^{\ominus}$  values added, award [0].)*

- (d) Seconds =  $2 \times 3600$  **OR** 7200 [1]
- Coulombs =  $8 \times 2 \times 3600$  **OR** 57 600 [1]
- $\div F$  =  $\frac{57\,600}{96\,480}$  **OR** 0.5970 [1]
- $\div 6$  =  $\frac{57\,600}{96\,480 \times 6}$  [1]
- Answer =  $0.099\,50 = 0.10(00)$  [1]

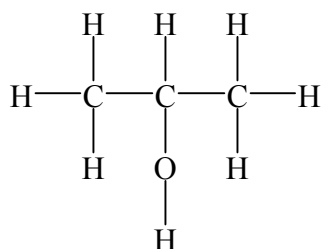
*(Correct answer with no working, [4 max].)*

**SECTION B**

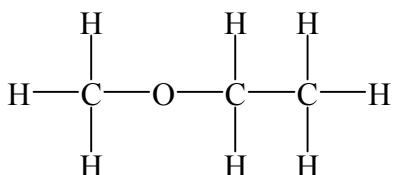
5. (a) (If lines are shown without H atom attached, penalise once only.)



1-propanol / propan-1-ol (I)  
(do not accept propanol)



2-propanol / propan-2-ol (II)



methoxyethane (III)  
(accept ether or alkoxyalkane)

3 × [1]

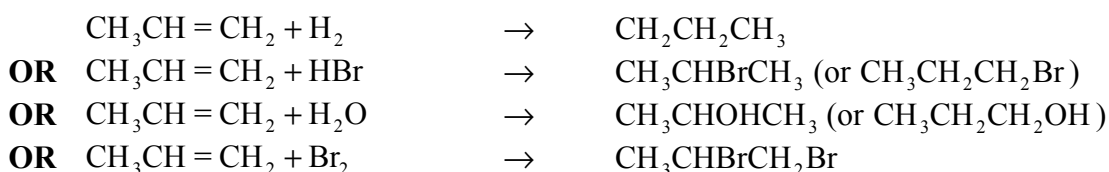
3 × [1]

- (b) (I) partially [1] oxidised [1] to CH<sub>3</sub>CH<sub>2</sub>CHO [1], propanal [1]  
(if state CH<sub>3</sub>CH<sub>2</sub>COOH propanoic acid instead of propanal, award [1])  
(II) oxidised (if not in (I), award [1]) to CH<sub>3</sub>COCH<sub>3</sub> [1], propanone [1]  
(I) or (II): orange to green [2]

- (c) alkanols show bands above 3000 cm<sup>-1</sup> [1]  
III is the choice [1]  
since it has C-O(-O) but no -O-H [1]

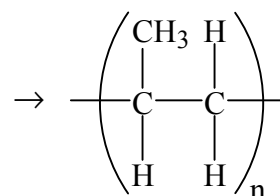
- (d) A is I [1] 3 Hs in CH<sub>3</sub>, 2 Hs in adjacent CH<sub>2</sub>, 2 Hs in next CH<sub>2</sub>, 1 H in OH [1]  
B is II [1] 6 Hs in the two CH<sub>3</sub>s, 1 H in CH, 1 H in OH [1]

- (e) I and II [1]  
both give CH<sub>3</sub>CH = CH<sub>2</sub> / CH<sub>3</sub>CHCH<sub>2</sub> [1]



Reagents [1]

Product [1]



idea of polymerisation [1]

content of bracket [1]

6. (a) (i) MgO ionic [1]  
 SiO<sub>2</sub> covalent [1]  
 both giant structures [1]  
 ionic bonds strong [1]  
 covalent bonds strong [1]  
 P<sub>4</sub>O<sub>6</sub> simple molecular [1]  
 SO<sub>2</sub> covalent [1]  
 weak intermolecular forces / bonds [1] [8]

(ii)

Oxide	Solubility	Acidic/Alkaline/Neutral
Magnesium	Soluble	Alkaline
Silicon	Insoluble	Neutral
Phosphorus	Soluble	Acidic
Sulphur	Soluble	Acidic

4 correct = [3]      4 correct = [3]  
 3 correct = [2]      3 correct = [2]  
 2 correct = [1]      2 correct = [1]      **max [6]**



(Accept suitable ionised versions, e.g. Mg<sup>2+</sup> + 2OH<sup>-</sup> instead of Mg(OH)<sub>2</sub>,  
 HSO<sub>3</sub><sup>-</sup> + H<sup>+</sup> instead of H<sub>2</sub>SO<sub>3</sub>.)

- (b) Ti 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>4s<sup>2</sup>3d<sup>2</sup> / [Ar] 4s<sup>2</sup>3d<sup>2</sup> [1]

Variable valency / oxidation

state / OWTTE [1] removal/sharing of several electrons [1]

coloured compounds [1] splitting of d orbitals, electron transitions [1]

complex compounds [1] accepting of electron pairs [1]

catalytic activity [1] complex formation/change of valency/can easily be oxidised or reduced [1]

any three [3]  
 plus appropriate reason [3]

7. (a) (i)  $\Delta H^\ominus$  is positive [1]  
 Reaction is endothermic (because products are at higher energy) [1]  
 Bonds in reactants must be stronger than those in products (because more energy must be added than is released). [1]
- (ii)  $\Delta G^\ominus$  is negative [1]  
 because reaction is spontaneous [1]  
 $\Delta S^\ominus$  is positive [1]  
 Since  $\Delta H^\ominus$  is positive,  $\Delta S^\ominus$  must be positive in order to make  $\Delta G^\ominus$  negative. [1]  
 ( $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$ )  
 Products must be more disordered than reactants. [1]
- (iii) **Known volumes** of reactant solutions at the **same temperature** are mixed and **temperature is monitored**. [3]  
 Mol of limiting reactant calculated from volume and **known concentration**. [1]  
 $q = \Delta T \times \text{mass of solution} \times C_p$  [1]  
 $\Delta H = q \text{ mol}^{-1}$  of limiting reactant [1]  
 Use of insulated reaction vessel [1]  
 Stir the mixture [1]
- Note:** [6] max which **must** include:  
 (a) known concentration of one volume;  
 (b) excess or equal reacting mols of second solution;  
 (c) temperature change;  
 (d)  $q = \text{mass} \times \text{specific heat capacity} \times \Delta T$
- (iv) If reactants do not react completely. [1]  
 If container is not insulated adequately, **heat will be gained from surroundings**. [1]  
 Insulate container sufficiently. [1]
- (v) Reaction becomes more spontaneous as  $T$  is increased [1]  
 less spontaneous as  $T$  is decreased. [1]  
 $T\Delta S^\ominus$  term will become larger as  $T$  is raised so  $\Delta G^\ominus$  will become more negative. [1]  
 $T\Delta S^\ominus$  term will become smaller as  $T$  is lowered so  $\Delta G^\ominus$  will become less negative (or even positive as  $+\Delta H^\ominus$  exceeds  $T\Delta S^\ominus$ ). [1]  
 (Accept arguments based on Le Chatelier's principle.)
- (b) (i)  $\Delta H_{\text{reaction}} = 2(\text{A—A}) \text{ bond energy} + \text{B—B bond energy} - 4(\text{A—B}) \text{ bond energy}$  [2]  
[1] for correct signs [1] for correct coefficients  
 (Number of bonds should be clear.)
- (ii) Tabulated bond energies are average values and may differ from those in specific compounds. [1]  
 The best agreement is achieved when few bonds are broken / specific bond energies are used / for gaseous reactions. [1]

