NN Classroom Mock Exam
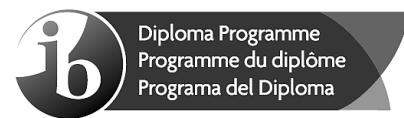
Chemistry

Higher level

Paper 2

Marking scheme

Where there is a will, there is a way.

1. (a) No. of moles of NaOH initially added = 1.0 x 25.00 / 1000 = 0.025 mol.

   (b) No. of moles of HCl = 0.050 x 16.50 / 1000 = 0.000825 mol.

      No. of moles of excess NaOH from the diluted sample = 0.000825 mol.

      No. of moles of excess NaOH from the original sample = 0.000825 x 10 = 0.00825 mol.

   (c) From pink to colourless.

   (d) No. of moles of NaOH that reacted with the acetyl-salicylic acid = 0.025 – 0.00825 = 0.01675 mol.

   (e) No. of moles of acetyl-salicylic acid = 0.01675 / 2 = 0.008375 mol.

      Mass of acetyl-salicylic acid = 0.008375 x 180 = 1.5075 g

      Percentage by mass = (1.5075 / 2.00) x 100 = 75.4 %

   (f) Assume no other compounds have reacted with the added NaOH except acetyl-salicylic acid from the tablet.

      Assume impurities are inert and do not react.

      Assume there is no other forms of salicylic acids from the tablet.

2. (a) Features of compounds belong to the same homologous series
      - Same general formula
      - Same functional group
      - Similar chemical properties (how a substance reacts)
      - Gradual change in physical properties as more carbon atoms are added
      - Adjacent members differ by a common structural -CH_2- unit

   (b) **Step 1**

      Reagent: Br_2 in organic solvent
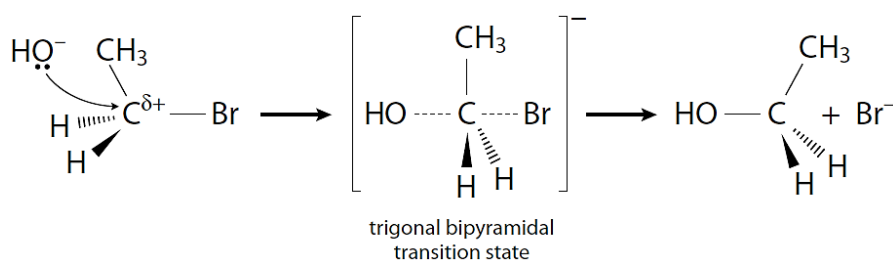
      Condition: UV

      Intermediate: Bromoethane

      Step 2

      Reagent: NaOH (aq)

      Condition: Heat

      Product: Ethanol

   (c)

trigonal bipyramidal
transition state

(d) S_N2:

    polar, protic solvents decrease nucleophilic reactivity due to hydrogen bonding

    OR

    polar, protic solvents have a cage of solvent molecules surrounding anionic nucleophile resulting in increased stabilization ‹so are slower›

    OR

    polar, aprotic solvents have no hydrogen bonding so SN2 reactions are favoured since nucleophiles do not solvate effectively so have an enhanced/pronounced effect on nucleophilicity of anionic nucleophiles ‹so are faster›

    S_N1:

    polar, protic solvents favour SN1 reactions since the carbocation ‹intermediate› is solvated by ion-dipole interactions by the polar solvent

3. (a) Slope = 1

    Chemical meaning = Rate order with respect to N_2O_5
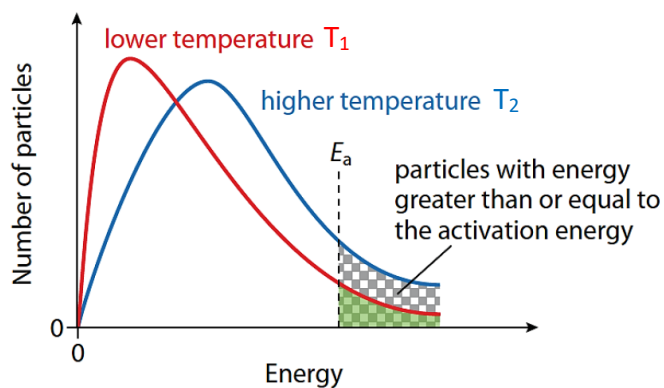
(b) y-intercept = -1.4

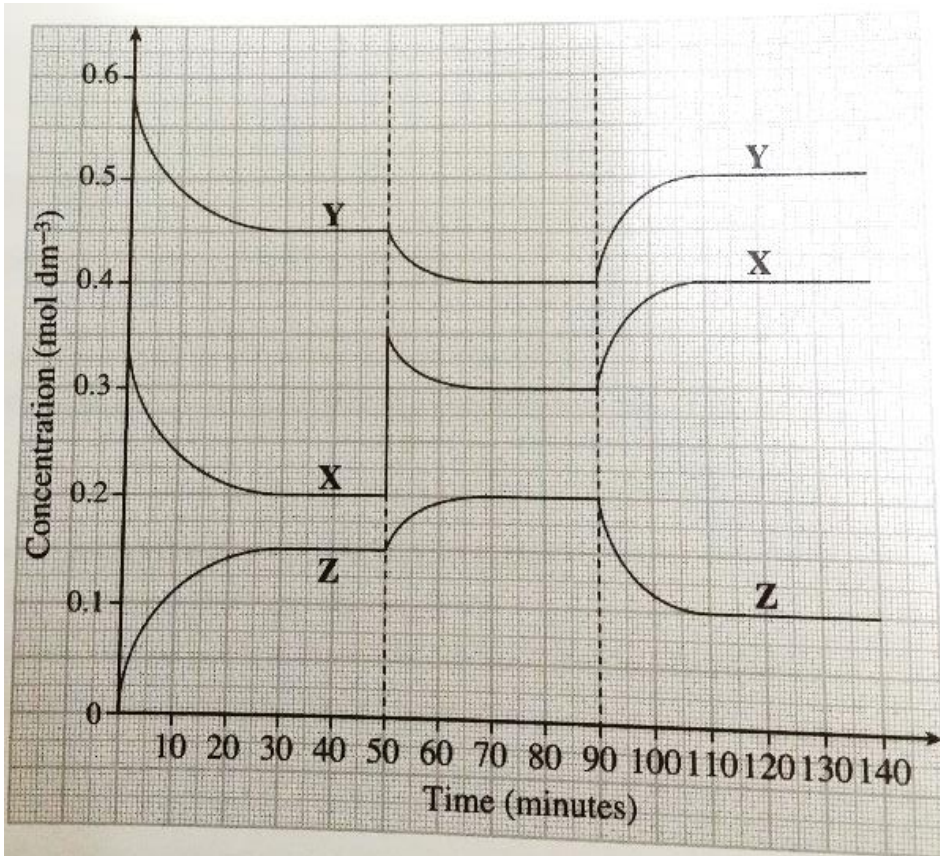   Chemical meaning = log (rate constant k)

(c) Rate constant = 0.040 s^{-1}

    Rate equation:

    Rate = 0.40 $[N_2O_5]$

(d)

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4. (a) & (bii) & (c)

(bi) Original equilibrium constant = 0.15 / (0.20 x 0.45) = 1.67 mol^{-1} dm^3

New initial concentration of **X** right after the addition of **X** = (0.2 x 2.0 + 0.3) / 2.0 = 0.35 mol dm^{-3}

New initial concentration of **Y** right after the addition of **X** = 0.45 mol dm^{-3}

New initial concentration of **Z** right after the addition of **X** = 0.15 mol dm^{-3}

Using R I C E table,

New equilibrium concentration of **X** = 0.3 mol dm^{-3}

New equilibrium concentration of **Y** = 0.4 mol dm^{-3}

New equilibrium concentration of **Z** = 0.2 ml dm^{-3}

(c) New equilibrium constant = 0.1 / (0.4 x 0.5) = 0.5 mol^{-1} dm^3

5. (a)
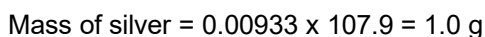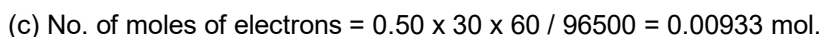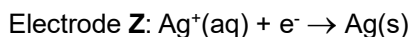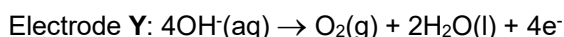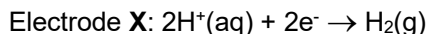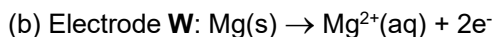   Beaker **A** acts as a voltaic cell, converting chemical energy into electrical energy by a spontaneous redox reaction.

      Magnesium is a stronger reducing agent than copper, so magnesium is preferentially oxidized so acting as the anode.
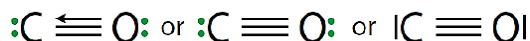
      Copper electrode thus acting as the cathode for reduction.

      Beaker **B** acts as an electrolytic cell, converting electrical energy into chemical energy by a non-spontaneous redox reaction.

   Aqueous silver nitrate is electrolyzed using the electricity generated by beaker A.

(b) Electrode **W**: $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

   Electrode **X**: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

   Electrode **Y**: $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

   Electrode **Z**: $Ag^+(aq) + e^- \rightarrow Ag(s)$

(c) No. of moles of electrons = 0.50 x 30 x 60 / 96500 = 0.00933 mol.

   No. of moles of silver = 0.00933 mol.

  Mass of silver = 0.00933 x 107.9 = 1.0 g

6. (a)

    :C $\equiv$ O: or :C $\equiv$ O: or IC $\equiv$ OI

(b) sp^2

(c) Electron domain geometry = Trigonal planar

   Molecular geometry = V-shaped / bent

   Bond angle = 117°

(d) $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$
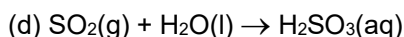
(e) **1. Pre-combustion methods**

    -     Performing hydrodesulfurization (hydrotreating) in fossil fuels e.g. coal, before the combustion

    -     This converts the sulfur to hydrogen sulfide (H_2S)

  2. Post-combustion methods

    -     To tackle with the sulfur dioxide, **scrubbers** are installed in the industrial plants in order to precipitate out the toxic gas.

    -     Passing the exhaust gases from the furnace through a vessel where the sulfur dioxide can react with alkalis / bases such as calcium oxide, calcium carbonate or calcium hydroxide.

    -     Calcium salts are used to precipitate out the SO_2 because $CaSO_3$ is insoluble in water.

        $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$
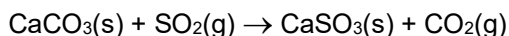
(f) Sulphur dioxide exists as a simple molecular structure.

   Molecules are held by weak intermolecular forces / Dipole dipole force.

   Less energy is required to overcome the interaction, so having a lower boiling point and existing as a gas.
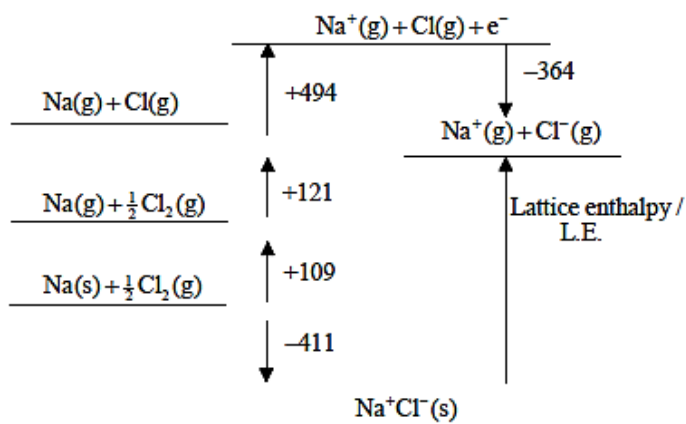

   Silicon dioxide exists as a giant covalent structure.

   Atoms are held by strong covalent bonds in a network.

   Much higher energy is required to overcome the interaction, so having a higher boiling point and existing as a solid.

7. (a) Hydration enthalpy is the enthalpy change when one mole of gaseous ions is surrounded by water molecules to form an 'infinitely dilute solution' under standard conditions.

Average bond enthalpy is the amount of energy required to break one mole of covalent bonds in gaseous state across a range of compounds with the same bond inside.
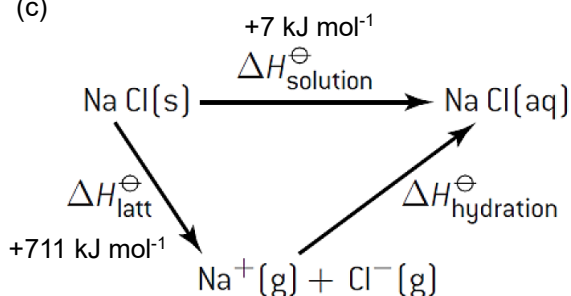
(b)

$$Na^+(g) + Cl(g) + e^-$$

$$Na(g) + Cl(g) \quad +494 \quad \xrightarrow{-364} \quad Na^+(g) + Cl^-(g)$$

$$Na(g) + \tfrac{1}{2}Cl_2(g) \quad +121 \quad \text{Lattice enthalpy / L.E.}$$

$$Na(s) + \tfrac{1}{2}Cl_2(g) \quad +109$$

$$-411$$

$$Na^+Cl^-(s)$$

correct endothermic changes;
correct exothermic changes;
$109 + 121 + 494 - 364 - L.E. = -411$;
$L.E. = +771 \, kJ\,mol^{-1}$; *(accept $-771 / 771 \, kJ\,mol^{-1}$)*   [4]
Units not needed for mark. Allow ECF from diagram.

(c)

$$NaCl(s) \xrightarrow[\Delta H^{\ominus}_{solution}]{+7\ kJ\ mol^{-1}} NaCl(aq)$$

$\Delta H^{\ominus}_{latt}$
$+711\ kJ\ mol^{-1}$

$\Delta H^{\ominus}_{hydration}$

$$Na^+(g) + Cl^-(g)$$

Total hydration enthalpies = $-(+711) + (+7) = -704$ kJ mol^{-1}

8. (a) Ethanoic acid is a weak acid as it undergoes partial / incomplete dissociation to form protons.

(b) $K_b = 1.00 \times 10^{-14} / 1.74 \times 10^{-5} = 5.75 \times 10^{-10}$

(c) Acid (such as HCl) added: $CH_3COO^- + H_3O^+ \rightarrow CH_3COOH + H_2O$

Base (such as NaOH) added: $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

(d) pH = pK_a = 4.76

(e) In ethanoic acid, there is no delocalization of pi electrons between the two C-O domains. So, there will be a difference in bond length where C-O is longer and C=O is shorter.

In ethanoate ion, there is delocalization of pi electrons between the two C-O domains. So, there will be an equivalence in bond length and it will be achieving a length sitting in between the C-O and C=O from the ethanoic acid. So, it will be shorter than C-O but longer than C=O.

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