PHYSICAL SCIENCES: PAPER II

MARKING GUIDELINES

Time: 3 hours

200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1

1.1	A	1.6	D
1.2	D	1.7	C
1.3	B	1.8	C
1.4	A	1.9	C
1.5	C	1.10	A

$$[10 \times 2 = 20]$$

QUESTION 2

2.1   When a molecule/molecular substance dissolves in water to produce ions
OR
Formation of ions
OR
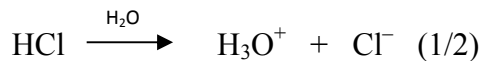Molecular substances produces/forms ions in water

NOT ACCEPTING – process where ions are released / breaking up /dissociation
– release of electrons   (2)

2.2 $HC\ell + H_2O \longrightarrow H_3O^+ + C\ell^-$ for H_2O for correct ions   (2)

OR $HCl \longrightarrow H^+(aq) + Cl^-(aq)$ for ions   for (aq)

$HCl \xrightarrow{H_2O} H^+ + Cl^-$ (1 / 2)

$HCl \xrightarrow{H_2O} H_3O^+ + Cl^-$ (1/2)

2.3   Covalent bonding (polar covalent)   (1)

2.4   A measure of the amount of <u>attractive force</u> that an atom can exert on a <u>shared pair of electrons</u>/bonding pair within a chemical bond.   (2)
OR
(A measure of the tendency of an atom to attract a bonding pair of electrons)

NOT ACCEPTING – anything to do with affinity

2.5

H = 2,1 Cℓ = 3,0 • e/neg difference = 0,9 • thus **polar covalent bond**	Ca = 1,0 Cℓ = 3,0 • e/neg difference = 2,0 • thus **ionic bond**

OR if use correct description using e/neg values for the relevant atom and describe their relative attractive forces on the shared electron pair (1 each)

Two non metal atoms combine = polar covalent (1/2)

Metal + non metal = ionic bond (1/2)   (4)

2.6   A molecular structure with two distinct regions of relative electrostatic charge.   (2)
OR
Molecular structure with asymmetrical charge distribution
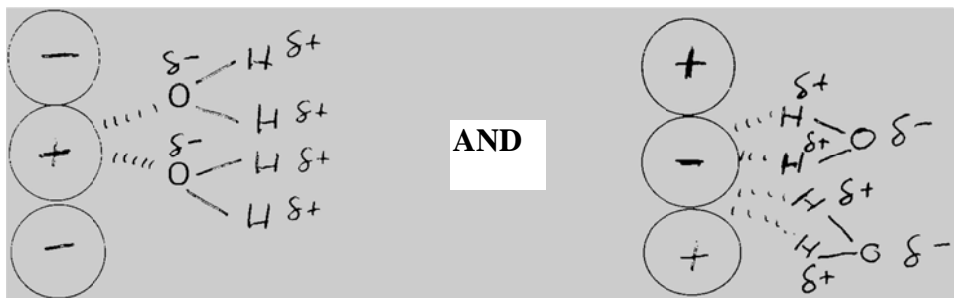**OR**
Molecule with partial positive and partially negative ends

(unequal sharing of electrons = ½)

NOT ACCEPTING – molecule with positive and negative end
                 – the drawing of HCL indicating polarity

2.7   2.7.1   Ionic (cubic)   (1)

2.7.2   Polar ends of the water molecule are attracted to ions in the lattice.

Cumulative forces of attraction between the ions and polar water molecule overcome the strong electrostatic forces within the lattice.
OR
Cumulative forces of attraction overcome the ionic bonds   (4)

NOT ACCEPTING – H-bonds are stronger than the ion dipole forces

ALTERNATIVE DRAWING – accepting the diagram showing hydrated ions with polarity indicated

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QUESTION 3

3.1   I = energy of reactants $E_{reactants}$ / Energy before reaction / Enthalpy of reactants
        II = activation energy   / E_A / Energy to break bonds
        III = energy released (on product formation) $E_{released}$ /   bonding energy
        IV = energy of products   / $E_{products}$
        V = heat of reaction / change in enthalpy / ΔH / enthalpy / change in **net** potential
        energy   (5)

        NOT ACCEPTING – I = initial energy / energy level
                                III = energy lost
                                 V = change in heat of reaction

3.2
    - Reactant particles must collide with or have sufficient energy for successful collision. Only those collisions with sufficient potential and kinetic energy equivalent to that of position B will be successful.
    - Allow for enough energy to break bonds
      OR
      Gain enough energy to form activated complex
      OR
   Activated complex is at a higher energy and is unstable   (2)

3.3
    - Activated complex / Transition State Complex
    - Position where old bonds are broken and new bonds are formed. (Formation of transition state complex.)   (2)

        NOT ACCEPTING – position where new bonds form
                                – Activa<u>tion</u> complex

3.4
    - Exothermic reaction
    - The amount of energy released on product formation is greater than the amount of energy absorbed to reach the activated complex.   (3)
      OR
    - Exothermic reaction
    - The amount of energy of the products is less than the amount of energy of the reactants.
      OR
    - Exothermic reaction
    - The heat (enthalpy) of the reaction will be negative / ($\Delta H < 0$)

        If they say Endothermic reaction – but with clear explanation (2/3) otherwise (0/3)

3.5
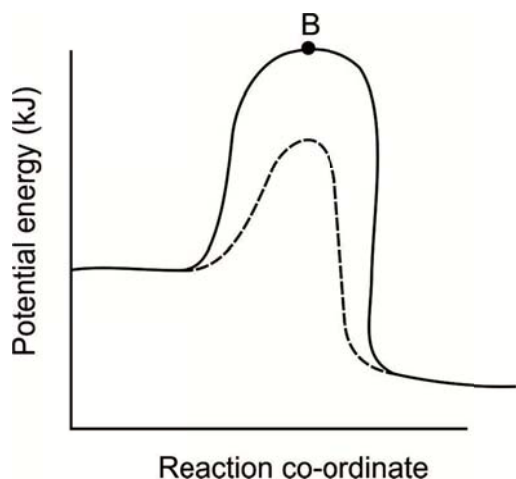
Activation energy less than B
Energy positions of both reactants
and the products unchanged

(2)

3.6

- No change
- Catalyst only lowers the energy of activation OR due to providing an alternative energy pathway and does not affect the final energy of the products formed.   (3)
  OR
  Does not change the energy of reactants and products
  OR
 I and IV remain constant

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QUESTION 4

4.1
- Carbon is able to form 4 covalent bonds (four available bonding sites)/ tetravalent/valency of 4
- Carbon is able to form multiple bonds with itself (single, double and triple bonds)
- Carbon is able to bond with itself to form chains (or rings) / catenation
  OR
  Forms a strong covalent bond with itself and other elements   (3)

NOT ACCEPTNG – 4 valence electrons / tetrahedral

4.2

H attached   ACCEPTED   double dot or double cross   (2)
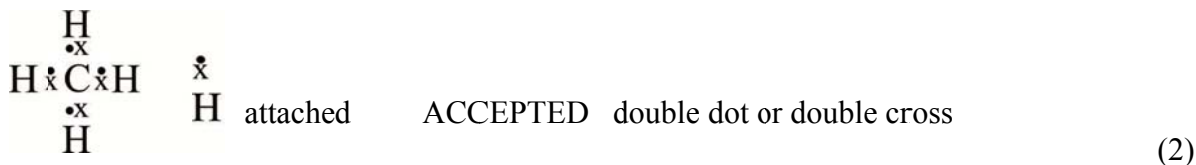
If used Couper notation – ½

NOT ACCEPTED – combination of Lewis and Couper

4.3 4.3.1 1 – Chloropropane   (2)

ACCEPTED   "-" between chloro and propane

NOT ACCEPTED   no "-" between 1 and chloro 1/2

4.3.2 E   (1)

4.3.3 (a) Alkyl halides/halogenoalkanes/ haloalkanes
       (b) Esters   (2)

4.3.4 D: Hydroxyl/hydroxy functional group
       F: Carboxyl functional group   (2)

ACCEPTED names with no letters only if in correct order

NOT ACCEPTED just a single name with no reference to letter

4.3.5
- Bromine water test/ test of unsaturation /test for double bonds/ Iodine test /
- Unsaturated compound (E) will cause Br_2 water to change from orange to colourless / discolouration / decolourise.
- Saturated compound (C) will not change the colour of the Br_2 water.
- E would undergo change much more rapidly that D (some mention of rate)   (3)

Both these to get 1 mark

4.3.6
- D has H-bonding between molecules.
- C has London (van der Waals) forces between molecules.
- H-bonding much stronger than London forces / dispersion.
- More energy needed to overcome H-bonding in D, hence remains liquid at room temperature. (4)

No reference to IMF or "between molecules" ......mark was deducted

4.3.7 $2C_3H_7OH + 9O_2 \longrightarrow 6CO_2 + 8H_2O$

$CO_2 + H_2O$
correct balancing (3)

If Stoichiometric coefficients were halved ....3/3 , if doubled 2/3

4.4   4.4.1   (a)   B
(b)   A
(c)   D
(d)   E (4)

4.4.2   (a)   KOH/NaOH / H_2O
(b)   HBr (2)

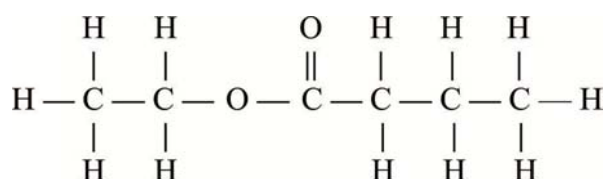4.4.3   (a)   Organic compounds with the same molecular formula but with a different structural formula. (2)

NOT ACCEPTED: different chemical structure

(b)   **Positional isomerism** – the functional group is at a different position in each isomer.

Functional isomerism – isomers which have different functional groups/ belong to different Homologous Series. (4)
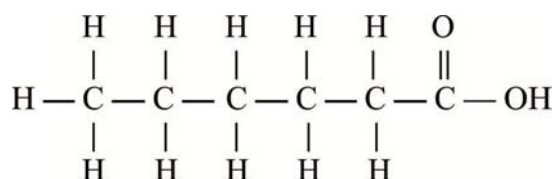
(c)   (i)

```
      H   H       O   H   H   H
      |   |       ||  |   |   |
  H — C — C — O — C — C — C — C — H
      |   |           |   |   |
      H   H           H   H   H
```

OR Alternative structures as per names in (ii) below

NOT ACCEPTED – the structure of propyl propanoate as it is from the question

```
      H   H   H   H   H   O
      |   |   |   |   |   ||
  H — C — C — C — C — C — C — OH
      |   |   |   |   |
      H   H   H   H   H
```
(2)

NOT ACCEPTED – if not in order as asked in question or not labelled 0/2

    (ii)   **Ethyl butanoate**
(also methyl pentanoate, butyl ethanoate, pentyl methanoate)
Hexanoic acid   (4)

Carry over only if linked correctly to (i) above

ACCEPTED – correctly drawn and named diols for functional isomerism

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QUESTION 5

5.1   When an external stress/disturbance (change in pressure, temperature or concentration) is applied to a system in equilibrium, the equilibrium will change in such a way as to counteract the stress /re-establish equilibrium / minimise the effect/oppose the change.   (3)

If did not mention system in equilibrium (–1)

5.2   A system where no external factors/influences/interferences/stress can influence the equilibrium.
OR
Substance cannot enter or leave the system / no particles or gases can enter or leave
OR
No change in mass / mass conserved
OR
No interferences on the system   (2)

ACCEPT – no variables affect the system (½)
             – no interaction/ contact with the environment (½)
             – a system which is isolated from its surroundings
             – no macroscopic changes (½)

5.3 $c = \dfrac{n}{v}$
       $n = cv$
          $= 6,5 \times 0,5$
          $= 3,25$ mol   (3)

If 500cm^3 used... (1/3)

5.4 $4 - 3,25$ (carry over error accepted)
       $= 0,75$ mol   (2)

ACCEPTED – the change in the number of moles $= -0,75$ mol

If used wrong volume in 5.3 , carry over allowed ....but if did the subtraction the wrong way around (Coe – 4).....then   ½

5.5   NO : O$_2$
        2   : 1
       $\therefore$ amount of O$_2$ used $= \dfrac{0,75}{2}$ (If showed dividing some number by 2 ....1/4)
                     $= 0,375$ mol   (accept 0,38 mol)
       $\therefore$ amount of O$_2$ at equilibrium $= 2,5 - 0,375$
                              $= 2,125$ mol (accept 2,13 mol)
       $\therefore c = \dfrac{n}{v} = \dfrac{2,125}{0,5} = 4,25$ mol·dm^{-3} (accept 4,26 mol.dm^{-3})   (4)

5.6 $K_c = \dfrac{[NO_2]^2}{[NO]^2[O_2]}$ (1)

5.7 $0,25 = \dfrac{[NO_2]^2}{(6,5)^2(4,25)}$ carry over of the expression and the value from 5.5

$[NO_2] = 6,7$ mol·dm^{-3}

$\qquad$ n = cv

$\qquad$ = 6,7 × 0,5

$\qquad$ = 3,35 mol   (4)

> It was noted that certain candidates did not complete this question, however did the rest of this question in 5.8. They were penalised in 5.7 but allowed the carry over if done in 5.8

5.8   NO : NO$_2$ $\qquad\qquad$ (carry over from 5.7)

$\quad$ 2 : 2

∴ n(NO$_2$) formed = 0,75 mol

∴ n(NO$_2$) at start = 3,35 – 0,75

$\qquad\qquad\qquad$ = 2,6 mol   (4)

PLEASE NOTE

If carry over answer used from 5.7 = 1 mark

Knowing that 0,75 mol of NO$_2$ was formed (or carry over from 5.4) = 1 mark

Subtracting 5.4 from 5.7 = 1 mark

If 5.4 is added to 5.7 .....only 2/4

5.9

- According to LCP, an increase in temperature will favour the reaction which removes energy from the system./ endothermic reaction
- A decrease in K$_c$ indicates that the back/reverse reaction is favoured / equilibrium shifts to the left / more reactants produced / fewer products formed
- Thus the forward reaction must be exothermic. (only if they have minimum of 1 other mark allocated to justification from above bullets ..... otherwise only 1 mark)   (5)

An increase in temp favour reaction which decreases temp ......only ½ for first bullet

[28]

QUESTION 6

6.1   6.1.1   Acid – proton donor
            Base – proton acceptor   (2)

      6.1.2   An acid that only partially ionises in aqueous solution (incomplete ionisation)   (2)

      6.1.3
            • H_3O^+ ions react with OH^-
            • H_3O^+ concentration decreases.
            • According to LCP – equilibrium position will change to minimise the stress (IE) to replace H_3O^+ ions.
            • Forward reaction is thus favoured increasing the In^- concentration.   (4)

6.2   6.2.1   A solution whose exact concentration is precisely known.   (2)

      6.2.2 $KOH(s) \longrightarrow K^+(aq) + OH^-(aq)$ (2)

      6.2.3 $c = \dfrac{n}{V}$ **OR** $c = \dfrac{m}{M \cdot V}$

              $\therefore n = cV$ $m = c \cdot M \cdot V$
              $\quad = 0,45 \times 0,25$ $\quad = 0,45 \times 56 \times 0,25$
              $\quad = 0,1125$ mol $\quad = 6,3$ g
              $n = \dfrac{m}{M}$
              $m = nM$
              $\quad = 0,1125 \times 56$
              $m = 6,3$ g   (5)

      6.2.4 $K_w = [H_3O^+][OH^-]$
              $KOH : OH^-$
              $\;\; 1 \; : \; 1$
              $\therefore [OH^-] = 0,45$
              $\therefore 1 \times 10^{-14} = [H_3O^+](0,45)$
              $\therefore [H_3O^+] = 2,22 \times 10^{-14}$ mol·dm^{-3} **OR** $10^{-13,653}$ mol·dm^{-3} (4)

      6.2.5   The point in the titration where the concentration of hydronium ions equals the concentration of hydroxide ions.   (2)

              (the point where an acid and base have reacted so neither is in excess)

      6.2.6 $n = cV$
              $\quad = 0,45 \times 0,015$
              $n = 0,00675$ mol
              $(6,75 \times 10^{-3}$ mol$)$ (2)

6.2.7 $(COOH)_2$: KOH
$$1 : 2$$
$$n = \frac{0,00675}{2}$$
$$\frac{n = 0,003375 \text{ mol}}{\left(3,375 \times 10^{-3}\right)}$$ (2)

6.2.8 $c = \dfrac{n}{V}$

$$= \frac{3,375 \times 10^{-3}}{0,025}$$
$$c = 0,135 \text{ mol·dm}^{-3}$$ (3)

6.2.9   The ability of ions of a dissociated salt to react with water molecules thus altering the pH of the solution.   (2)

6.2.10

- Phenolphthalein
- $(COOK)_2 \longrightarrow 2K^+ + 2COO^-$
  $2H_2O \rightleftharpoons H_3O^+ + OH^-$
  COO^- ions react with H_3O^+ to form $(COOH)_2$
- Weak equilibrium upset by the removal of H_3O^+ – forward reaction now favoured.
- More OH^- released into solution, thus increasing the pH, hence forming a basic solution.   (4)

[36]

QUESTION 7

7.1   7.1.1   A solution that is able to conduct electrical charge by the movement of ions through that solution.
                OR solution containing free or mobile charged particles   (2)

                NOT ACCEPTING – a liquid that will conduct

        7.1.2   Part of an electrochemical cell which consists of an electrode placed in an electrolyte.
                OR portion of e/chem. cell where a half reaction (reduction/oxidation) takes place   (2)

7.2   Chemical energy converted to electrical energy.   (2)

7.3   Silver nitrate   (1)

7.4   Concentration of electrolyte = 1 mol·dm^{-3}
        Temperature = 25 ºC (298 K)   (2)

        ACCEPT concentration = 1 mol.dm^{-3}

        NOT ACCEPT pressure (–1 off answer if used)

7.5   Cobalt half cell   (1)

7.6   Increase – reduction occurs at the cathode causing metal ions (Ag$^+$) to gain electrons to form the metal (Ag) which coats the electrode increasing its mass
        (Ag$^+$ + e$^-$ $\longrightarrow$ Ag)   (3)

        NOTE: If 7.5 was given as silver, then 7.6 must relate to cobalt
              If gave half reaction with double arrows, (–1)
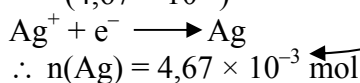
7.7   Q = It
          = 0,75 × 600
          = 450 C

        No. of e$^-$ transferred = $\dfrac{450}{1,6 \times 10^{-19}}$ $\qquad$ ne$^-$ = $\dfrac{450}{96\,500}$

                          = 2,81 × 10^{21} electrons   ne$^-$ = 4,66 × 10^{-3} mol of e$^-$

        n = $\dfrac{N}{N_A}$

          = $\dfrac{2,81 \times 10^{21}}{6,02 \times 10^{23}}$

          = 0,00467 mol of electrons
            (4,67 × 10^{-3})

        Ag$^+$ + e$^-$ $\longrightarrow$ Ag
        ∴ n(Ag) = 4,67 × 10^{-3} mol

        n = $\dfrac{m}{M}$

        m = nM
          = 4,67 × 10^{-3} × 108
          = 0,5 g of Ag   (5)

7.8 $Co + 2Ag^+ \longrightarrow Co^{2+} + 2Ag$ (–1 for each error....especially using CO)   (3)
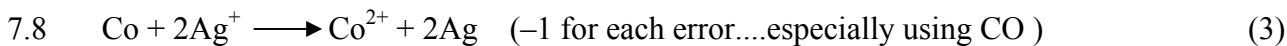
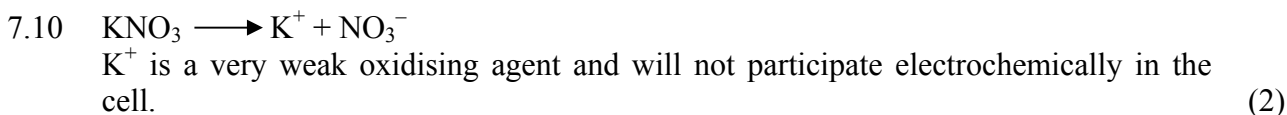7.9

- As cell functions – **increase** in cation concentration in anode and **decrease** in cation concentration in cathode.
- Anions (NO_3^- (aq)) will move into anode half cell to <u>balance out</u> excess cations.
- Cations (K^+) will move into cathode half cell (Ag half cell) to <u>balance out</u> shortage of cations (Ag^+).   (4)
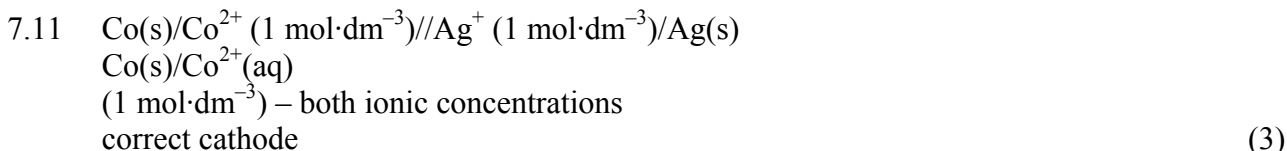
NOT ACCEPTING: in bullets 2 and 3 ....not accepting "just maintains neutrality"
If statements refer to electrons causing electrolyte to become positive or negative

WILL ACCEPT: anions to anode and cations to cathode ....1 mark only

7.10 $KNO_3 \longrightarrow K^+ + NO_3^-$
K^+ is a very weak oxidising agent and will not participate electrochemically in the cell.   (2)

ACCEPT: All nitrates are soluble therefore cannot form precipitates
KNO_3 is unreactive (only ½)

NO ACCEPT: K is a strong reducing agent

7.11 $Co(s)/Co^{2+}$ (1 mol·dm^{-3})//Ag^+ (1 mol·dm^{-3})/Ag(s)
$Co(s)/Co^{2+}(aq)$
(1 mol·dm^{-3}) – both ionic concentrations
correct cathode   (3)

If no concentrations shown 2/3
If conc and/or temp written below ....ACCEPTED (Mind Action Series)
If pressure used (–1) if not already penalised in 7.4

[30]

QUESTION 8

8.1   Electro-refining / electro-winning / Electrolytic refinement   (1)

8.2 $Cu^{2+} + 2e \longrightarrow Cu$ (1)

8.3   8.3.1   Cu is a stronger reducing agent than water thus will be preferentially oxidised.   (2)
                OR
                Cu has a lower reduction potential than water, this preferentially oxidised

                NOT ACCEPTING: H_2O is a stronger oxidising agent
                                 Referring to position on table
                                 Will not be spontaneous due to the "C"

        8.3.2
                • Fe and Zn have a more negative half cell potential compared to potential difference (0,34V) applied.
                • Fe and Zn will thus be oxidised.
                • Au and Ag have a more positive half cell potential compared to the potential difference – cannot be oxidised.   (3)

                ACCEPT: Fe and Zn half cell potential less than 0,34V, Au and Ag half cell potential greater than 0,34 – thus Zn and Fe will be oxidised

                Fe and Zn are stronger reducing agents than Au and Ag, therefore it takes lower voltages for them to oxidise. The applied potential of 0,34V is sufficient for Fe and Zn to be oxidised (insufficient for Ag and Auto oxidise)

        8.3.3 Fe^{2+} and Zn^{2+} are weaker oxidising agents than Cu^{2+}.   (2)
                OR
                Cu^{2+} is a stronger oxidising agent than Fe^{2+} and Zn^{2+}

8.4 $Cu^{2+} + Cu \longrightarrow Cu + Cu^{2+}$ OR $CuSO_4 + Cu \longrightarrow Cu + CuSO_4$

        OR

        Cu (impure) $\rightarrow$ Cu (pure)   (2)
                                                     [11]

Total: 200 marks