NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2023

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 MULTIPLE CHOICE

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

QUESTION 2

2.1 $4A\ell + 3O_2 \rightarrow 2A\ell_2O_3$ reac prod
Bal (only if reactants and products correct)

2.2 2.2.1 ionic bonding; many strong electrostatic forces of attraction that need a lot of energy to be overcome **OR** ionic bonds that need a lot of energy to be broken.

2.2.2 Ions are fixed in position / cannot move.

2.3 Aluminium has metallic bonding. Fixed lattice of positive kernels/cations and a sea of (delocalised) electrons that are free to move.

2.4 2.4.1 atoms

2.4.2
- H_2Te has more electrons/energy levels than H_2Se.
- H_2Te forms stronger dipole-dipole forces than H_2Se (both substances have angular/bent molecules).
- More energy needed to overcome IMF between H_2Te molecules (larger molecule)

2.4.3 electrons are <u>equally</u> shared because there is <u>zero difference in electronegativity</u>.

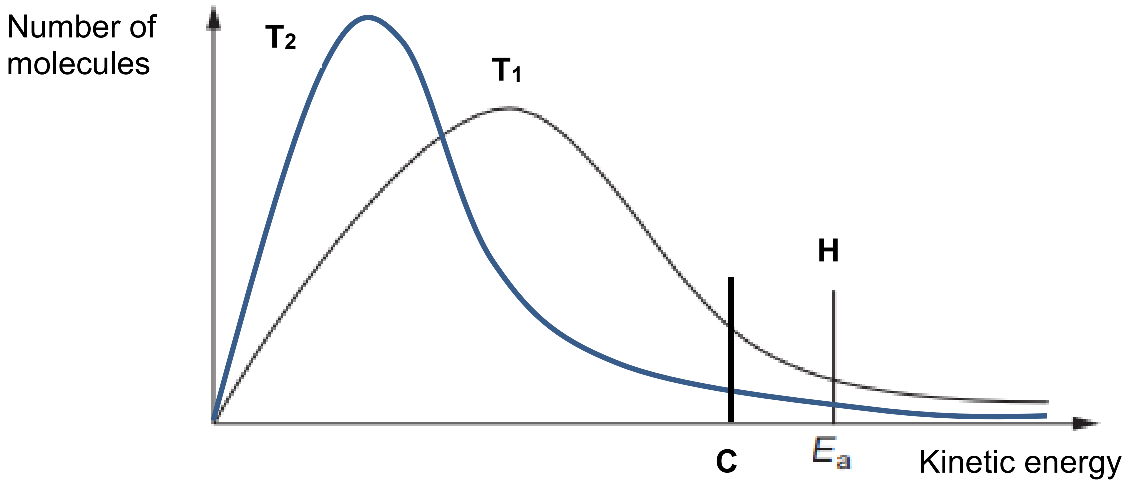
2.5 2.5.1 London / dispersion / induced dipole

2.5.2 As the oxygen molecules **approach each other** (get close)
there is a **dispersion of the electrons** in each oxygen molecule
OR the electron could become **unevenly distributed**
resulting in **induced / temporary dipoles** forming
which are then able to **attract** each other.

QUESTION 3

3.1 3.1.1 (a) **T_2** peak higher and to the left and below T_1 curve on the right

(b) **H** in same position as E_a



3.1.2 The minimum energy required to start a chemical reaction
OR the energy required to form the activated complex.

3.1.3 A substance that increases the rate of the reaction but remains unchanged at the end of the reaction.

3.1.4 **C** line to the left of E_a

3.1.5 Since there are more particles with **kinetic** energy (E_k) ≥ E_a, there will be more effective (OR successful) collisions per unit time.
NOTE: there are NOT **MORE COLLISIONS.**

3.2 3.2.1 Decreases. The volume / amount of CO_2 produced in each time interval decreases.
OR: Calculate two rates and compare.

3.2.2 As the concentration of the solution and the amount of solid decrease, there are fewer effective collisions per unit time between reacting particles.

3.2.3 (a) $n(HC\ell) = cV = 0{,}1 \times 0{,}1 = 0{,}01$ mol

EITHER: 0,04 mol $CaCO_3$ needs 0,08 mol $HC\ell$ (>0,01 mol)
OR: 0,01 mol $HC\ell$ reacts with 0,005 mol $CaCO_3$ (<0,04 mol)
∴ ($CaCO_3$ is in excess and) $HC\ell$ is LR

(b) $n(CO_2)$ formed = 0,01 / 2 = 0,005 mol coe
$V(CO_2) = nV_m$
$V_m = V / n = 120 / 0{,}005 = 24\ 000\ cm^3{\cdot}mol^{-1} = 24\ dm^3{\cdot}mol^{-1}$
OR $0{,}12 / 0{,}005 = 24\ dm^3{\cdot}mol^{-1}$

3.2.4 Decrease

QUESTION 4

4.1 FALSE

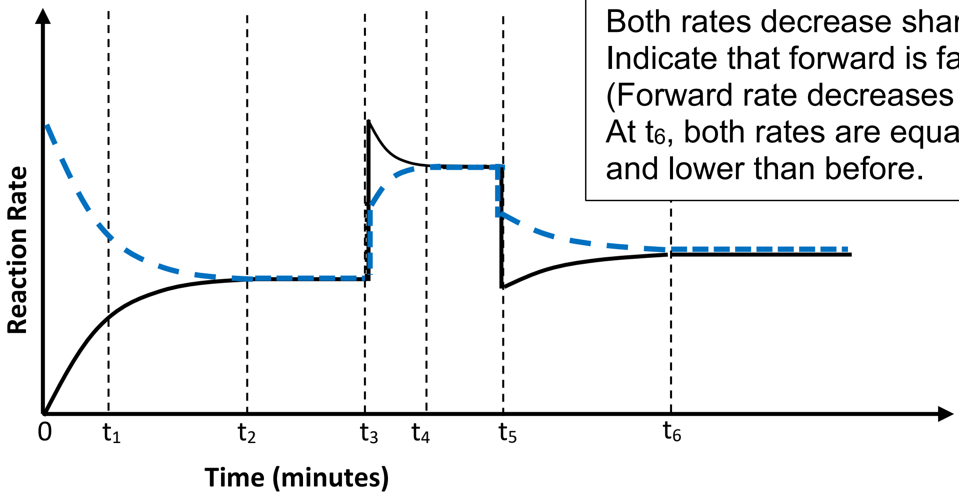
4.2 The rate of the forward reaction ($2AB \rightarrow 2A + B_2$)

4.3 constant

4.4 (coe from 4.2) A temperature increase causes an endothermic reaction to be favoured because it will absorb heat and thereby reduce the temperature.
The graph shows that the reverse reaction is favoured.
The forward reaction is exothermic.

4.5 4.5.1 The forward reaction is favoured (faster than reverse)
as it produces more particles of gas
and thereby increases the pressure.

4.5.2



coe from 4.5.1
Both rates decrease sharply at t_5.
Indicate that forward is favoured
(Forward rate decreases less.)
At t_6, both rates are equal
and lower than before.

4.6 4.6.1 $K_c = \frac{[A]^2[B_2]}{[AB]^2}$ top bottom -1 if no square brackets

4.6.2 $1,56 \times 10^{-3} = \frac{(0,05)^2(0,025)}{[AB]^2}$ all correct

$[AB] = 0,2\ mol \cdot dm^{-3}$ (given)

4.6.3 Concentration of AB that reacts = 0,025 × 2 = 0,05 $mol \cdot dm^{-3}$
Starting concentration of AB = 0,2 + 0,05 = 0,25 $mol \cdot dm^{-3}$

OR

R(ratio)	2AB	⇌	2A	+	B_2
I(initial)	**X**		0		0
C(change)	−0,05		+ 0,05		+0,025
E(equilibrium)	0,2		0,05		0,025

X – 0,05 = 0,2
X = $[AB]_{initial}$ = 0,25 $mol \cdot dm^{-3}$ with unit

QUESTION 5

5.1 5.1.1 The reaction of a molecular substance with water to produce ions.

5.1.2 A substance that can act as either an acid or a base.

5.1.3 HSO_3^- and H_2O

5.1.4 a proton acceptor

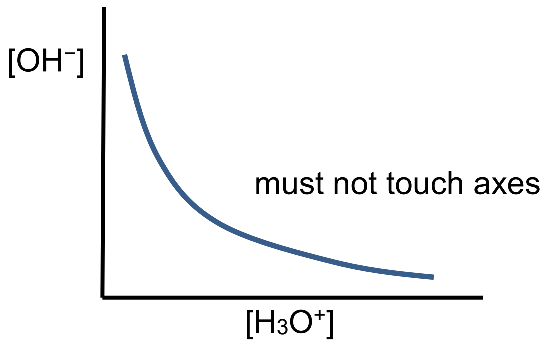
5.1.5 H_2O and SO_3^{2-}

5.1.6 It ionises only partially $\therefore$ HSO_3^- is a weak acid

5.1.7 sulfurous acid

5.1.8 The $[SO_3^{2-}]$ will decrease
The reaction that increases the $[SO_3^{2-}]$ / produces sulfite will be favoured
Forward reaction is favoured
$[H_3O^+]$ increases
pH decreases

5.1.9



5.2 5.2.1 $n(H_2SO_4) = cV = 1 \times 0,05 = 0,05$ mol

5.2.2 $n(NaOH) = cV = (0,5) \times (0,028) = 0,014$ mol

Ratio is 2:1 therefore 0,014 / 2 = 0,007 mol

5.2.3 0,05 (coe) – 0,007 = 0,043 mol coe from 5.2.1 and 5.2.2

5.2.4 $n(MgCO_3) = 0,043$ mol (1:1) coe from 5.2.3
$m(MgCO_3) = nM = 0,043 \times 84,3 = 3,62$ g
% purity = 3,62 / 5 × 100 = 72,5%

QUESTION 6

6.1 A $C\ell_2$
B $C\ell^-$
C Pt
D Fe^{2+}, Fe^{3+} (both)

6.2 6.2.1 salt bridge

6.2.2 **Formula of** any Group 1 metal nitrate e.g. KNO_3

6.2.3 an electrolyte (ions present) / conducts electricity, (highly) soluble / inert

6.3 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$
$= 1,36 - 0,77 = 0,59$ V

6.4 Fe^{2+} or iron(II) (ion)

6.5 Y to X
the wire

6.6 $2 \times Fe^{3+}$ ions are produced per mol of $Fe_2(SO_4)_3$; therefore use a concentration of 0,5 $mol \cdot dm^{-3}$ since it will produce $[Fe^{3+}]$ of 1 $mol \cdot dm^{-3}$

6.7 $[Fe^{3+}]$ will decrease more than $[Fe^{2+}]$
The forward reaction will be favoured to increase the $[Fe^{3+}]$
The emf will increase (coe).

QUESTION 7

7.1 A (concentrated aqueous) solution of sodium chloride OR $NaC\ell(aq)$

7.2 Electrical to chemical energy

7.3 X = $C\ell_2$ **OR** chlorine
Y = H_2 **OR** hydrogen
Z = NaOH **OR** sodium hydroxide **OR** caustic soda

7.4 P = $C\ell^-$ or chloride
S = H_2O or water

7.5 Q = Na^+ **OR** sodium ions

7.6 The OH^- ions could get oxidised to oxygen gas which would contaminate the product

$$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$$

7.7 Mercury cell – mercury is a toxic heavy metal; environmental pollutant and health hazard; there are costs involved in removing Hg from effluent; the cell is more expensive to operate

Diaphragm cell
- – product NaOH solution is very dilute and contaminated with $NaC\ell$
- – Uses asbestos for diaphragm – health hazard
- – More expensive to operate; costs involved in replacing asbestos diaphragm regularly and further evaporation of NaOH(aq) to increase its concentration

QUESTION 8

8.1 8.1.1 A series of similar compounds that have the same functional group and general formula, in which each member differs from the previous one by a single $-CH_2$ unit

8.1.2 alkanes

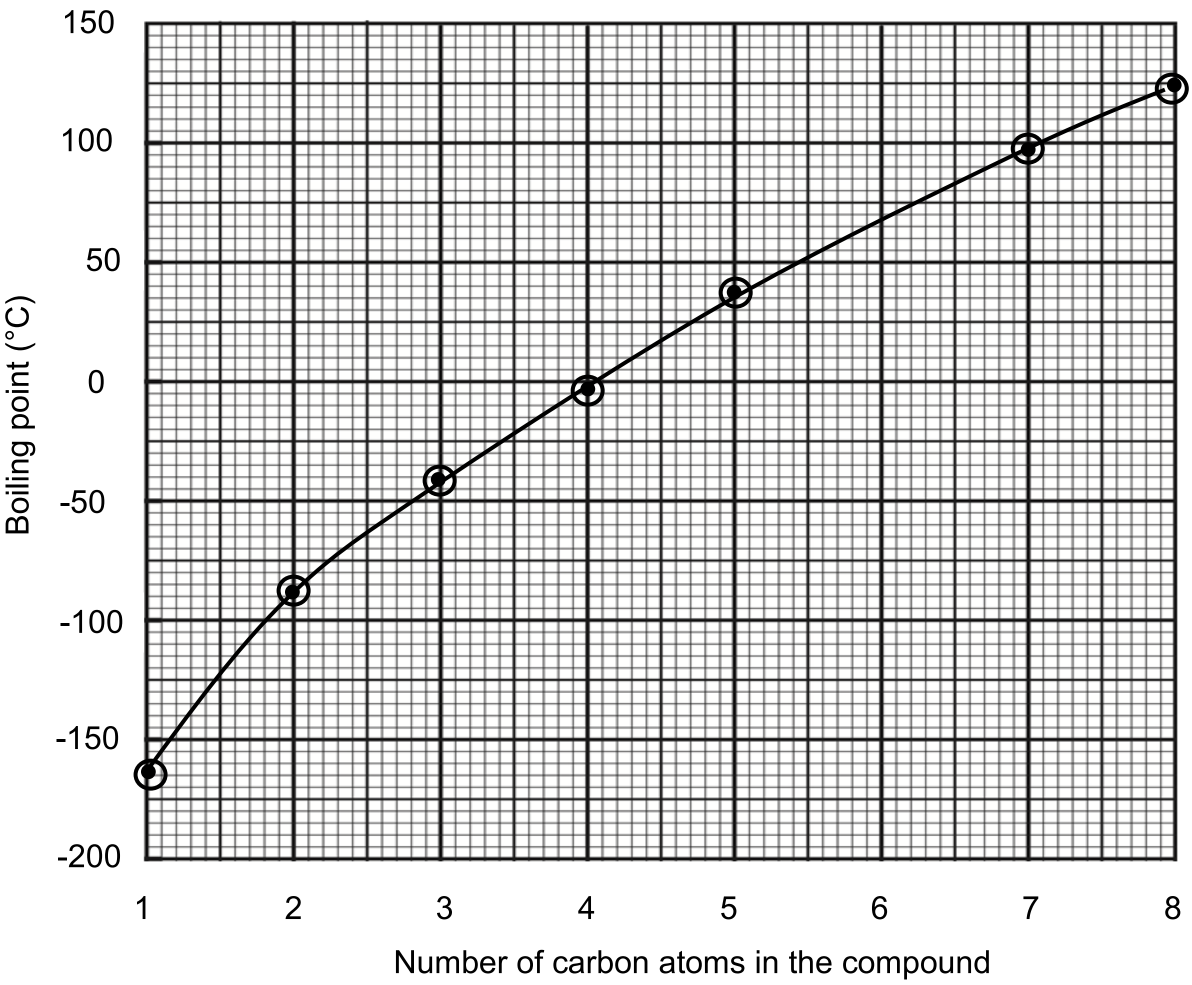
8.1.3 saturated

8.1.4 $C_{20}H_{42}$

8.2 carboxyl

8.3 Only one point correct all points correct best-fit curve

Boiling points of Table A compounds



8.4 hexane b.p. ≅ 69°C (read accurately from curve drawn)

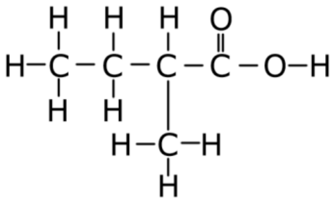
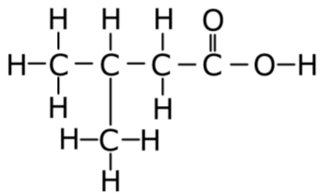
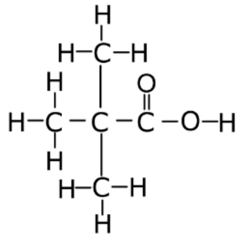
8.5 pentane, hexane, heptane, octane
Only alkanes (hydrocarbons) listed.
All four correct.

8.6 8.6.1 CH_3COOH / CH_3CO_2H or semi-structural formula

8.6.2 It is a controlled (fixed) variable / so that it is a fair test / molar mass affects b.p. The molecules will / must have similar strength London forces.

8.6.3 Ethanoic acid has hydrogen bonding intermolecular forces (in addition to London forces). Butane only has London forces. The intermolecular forces between the ethanoic acid molecules are stronger. More energy is needed to overcome them.

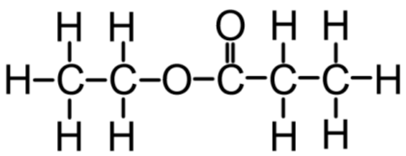
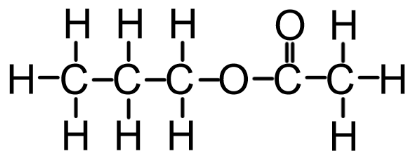
8.7 8.7.1 STRUCTURAL formula (show all bonds) of

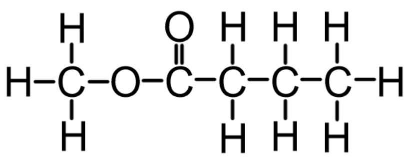
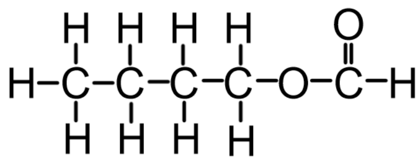
2-methylbutanoic acid OR 3-methylbutanoic acid
OR dimethylpropanoic acid

Must be 5C carboxylic acid chain isomer all correct

8.7.2 STRUCTURAL formula (show all bonds) of

ethyl propanoate OR propyl ethanoate

OR methyl butanoate OR butyl methanoate

Must be ester 5C all correct
–1 in total if condensed structural formula drawn in 8.7.1 or 8.7.2
–1 in total if H's omitted

8.7.3 name corresponds to structure in 8.7.2: -yl …-anoate

QUESTION 9

9.1 The average of the data should be included.
Units should appear only in the column heading.

9.2 Repetition ensures that results are reliable (accurate) and minimises the effect of random errors.

9.3 hydrolysis

9.4 butan-1-ol

9.5 C—Cℓ bond is strongest.
Chlorobutane takes longest to react / reacts slowest (must refer to data).

9.6 9.6.1 dehydrohalogenation

9.6.2 $CH_3CH_2CH_2CH_2C\ell \rightarrow CH_3CH_2CH{=}CH_2 + HC\ell$

OR

$CH_3CH_2CH_2CH_2C\ell + KOH \rightarrow CH_3CH_2CH{=}CH_2 + (KC\ell + H_2O)$

Total: 200 marks