NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2016

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 D
1.2 B
1.3 C
1.4 D
1.5 B
1.6 A
1.7 C
1.8 A
1.9 D
1.10 B **[10 × 2 = 20]**

QUESTION 2 CHEMICAL BONDING

2.1 2.1.1 It is a bond occurring between atoms within molecules. (1)

2.1.2 Polar/covalent/bond. (2)

2.1.3 A (weak) force of attraction between molecules or between atoms of noble gases. (2)

2.1.4 Hydrogen bond (Hydrogen bonding intermolecular force). (1)

2.1.5 It is a (small) atom with a high electronegativity and it has at least one lone pair of electrons. (2)

2.1.6 δ^+ (allow positive; +; α^+) (1)

2.2 2.2.1 A transfer of electrons and subsequent electrostatic attraction. (2)

2.2.2* • Large number of STRONG electrostatic forces (ionic bonds, coulombic forces) of attraction between ions in giant network structure.
• Large amount of energy required to break/overcome these forces. (3)

2.2.3 Ion-dipole force (1)

2.2.4 **Sodium ion (Na^+)**. The water molecules are orientated in such a way that the (slightly) negative oxygen atoms (δ^-) are closest to the positive ion. (2)
c.o.e. from 2.1.6
$C\ell^-$ The water molecules are orientated in such a way that the (slightly) positive oxygen atoms are closest to the positive ion.
If 2.1.6 is wrong no mark is given in 2.2.4 for either Na^+ or $C\ell^-$ without justification.

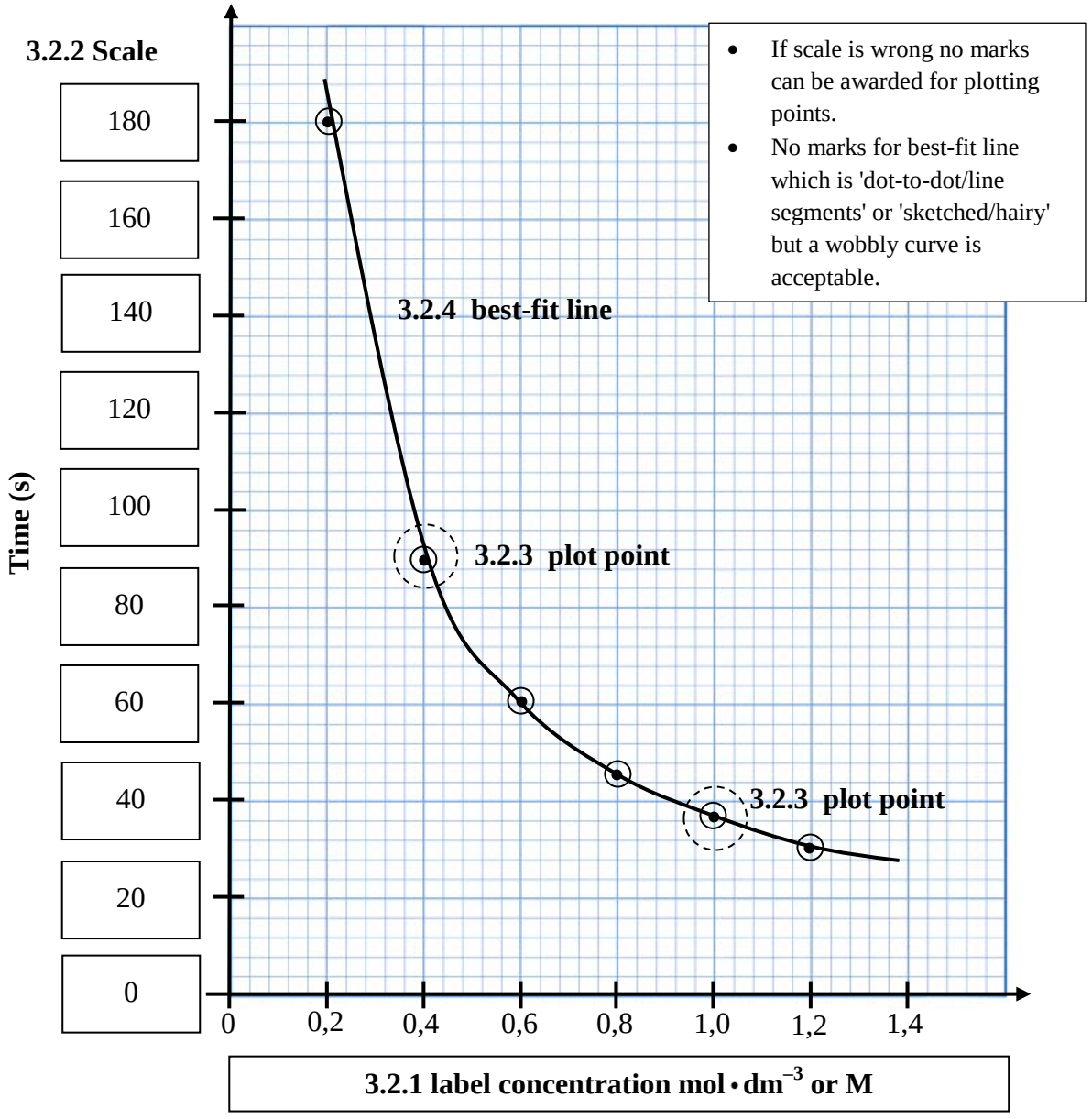
2.2.5* The electrostatic forces (ionic bonds) holding the ions in the crystal lattice are much **stronger** than the ion-dipole forces between the ions and the water molecules. Large numbers of water molecules need to **surround each ion** in order to **overcome the strong electrostatic force**s and "pull" the ion out of the lattice. (3)
[20]

***** Penalise wrong use of terminology (e.g. atoms instead of ions) **once** in total in Question 2.2.2 and Question 2.2.5

QUESTION 3 ENERGY CHANGE AND REACTION RATES

3.1 (Sulphur) is insoluble/solid/precipitate/murky/opaque/turbid and blocks the light. (2)
Don't give a mark for saying there is a decrease in light intensity as that is stated in the question.

3.2



Graph (6)

3.3 Time is the **dependent variable** OR **time depends on concentration.** (1)
No marks for stating 'time is measured'.

3.4 Straight line, which passes through the origin (0). Correct sketch of graph (one mark only). Ignore reference to positive or negative slope. (2)

3.5 The reaction **rate increases** as there are **more particles** (of $Na_2S_2O_3$) **per unit volume** therefore **more effective** (correct orientation and sufficient activation energy) **collisions** per unit time. (3)

3.6 Place the flask containing the sodium thiosulphate solution on top of a large black cross drawn on a piece of white paper. Carry out step 2 of the original method but **stop the watch when the cross is no longer visible** when viewed through the solution from above. OR Measure change in mass/pressure/volume of gas collected/pH with **time**. (2)

3.7 3.7.1 $n = c.V$
$= 0,2 \times 0,1$ (conversion)
$=$ **0,02 mol** of $HC\ell$ (2)

3.7.2 mol ratio $HC\ell : S$
$2 : 1$
$0,02 : 0,01$

$m = n \times M$
$= 0,01 \times (32)$
$= 0,32$ g

% yield $= \frac{0,18}{0,32} \times 100$ (method)
= 56,25%

IF one error only (eg wrong molar mass of S or wrong ratio) gets 3/5

OR 3.7.1* $n_{sulphur} = \frac{m}{M}$
$= \frac{0,18}{32}$
$= 0,005625$ mol
mol ratio **HCℓ** : S
2 : 1
0,01 mol (2d.p.) **0,01125** : 0,005625

OR 3.7.2* If do alternative given above then
$n = c.V$
$= 0,2 \times 0,1$ (conversion)
$=$ **0,02 mol** of $HC\ell$
% yield $= \frac{0,01125}{0,02} \times 100$
= 56,25%
OR n = m/M = 0,18/32 = 0,005625 mol of S
% yield $= \frac{0,005625}{0,01} \times 100$ (method)= **56,25%**

(5) **[23]**

QUESTION 4 CHEMICAL EQUILIBRIUM

4.1 As A_2B decomposes in the forward reaction, the **concentration of A_2 and B_2 (or product) increases** OR more particles of $A_2$and B_2. (2)

4.2 4.2.1 There has been an **increase in concentration (or pressure)** of **both reactants and products**. (2)

4.2.2 Reverse (1)

4.2.3 The reverse reaction is favoured since it leads to the formation of **fewer moles of gas**, which **relieves the stress of high pressure** (or **lowers the pressur**e). (NO c.o.e. from 4.2.2) (2)

4.3 Exothermic.

- Stress: Decrease in temperature.
- Response: Reverse reaction rate decreases more than forward reaction rate, therefore **forward reaction favoured**.
- Reason: Forward reaction produces heat (exothermic) in order to relieve the stress (raise the temperature). (3)

4.4 A catalyst is added. (1)

4.5 No change in $[A_2B]$. The rates of BOTH forward and reverse reactions have increased. **EQUALLY** or whilst **remaining in equilibrium OR** A_2B being broken down and produced at the same rate. (3)

4.6 4.6.1 No effect. (1)

4.6.2 Increases.

Must be consistent with 4.3 If state **ENDO** in 4.3 then must state **decrease** in 4.6.2 (1)

4.7 4.7.1 $V = \frac{n}{c}$

$= \frac{3,6}{1,2}$

$= \mathbf{3\ dm^3}$ (2)

4.7.2 $K_c = \frac{[A_2]^2 \cdot [B_2]}{[A_2B]^2}$ ( ) -1 mark (2)

4.7.3 $[\mathbf{A_2B}]$ = n/V

$= \frac{(5,1 - 3,6)}{3}$ method or $\frac{1,5}{3}$ ÷ **volume**

$= 0,5\ mol \cdot dm^{-3}$

$[\mathbf{B_2}]$ = n/V

$= \frac{1,8}{3}$

$= 0,6\ mol \cdot dm^{-3}$

c.o.e. volume from Question 4.7.1

OR TABLE

MOLE table

$\mathbf{2A_2B_{(g)}} \rightleftharpoons$	$\mathbf{2A_{2(g)}}$	+ $\mathbf{B_{2(g)}}$
*Mole ratio	2	2	1
Moles at start	**5,1**	0	0
*Moles used/formed	3,6	3,6	1,8
Moles at equilibrium	(5,1 – 3,6) = 1,5	**3,6**	1,8
Conc. at equilibrium ($mol \cdot dm^{-3}$) (c = n/V) (V = 3 dm^3)	(1,5/3) = 0,5	**1,2**	1,8/3 = 0,6

÷ vol

CONC table

$\mathbf{2A_2B_{(g)}} \rightleftharpoons$	$\mathbf{2A_{2(g)}}$	+ $\mathbf{B_{2(g)}}$
*Mole ratio	2	2	1
Conc at start	5,1/3 = 1,7	0	0
*Conc change	1,2	1,2	0,6
Conc. at equilibrium ($mol \cdot dm^{-3}$) (c = n/V) (V = 3 dm^3)	(1,7 – 1,2) = 0,5	**1,2**	0,6

$K_c = \frac{[A_2]^2 \cdot [B_2]}{[A_2B]^2}$ c.o.e. K_c from Question 4.7.2

$= \frac{1,2^2 \times 0,6}{0,5^2}$ subst

$= \mathbf{3,46}$ (6)

[26]

QUESTION 5 QUANTITATIVE CHEMISTRY AND ACIDS AND BASES

5.1 5.1.1 A solution of known concentration. (1)

5.1.2 **Error & correction** (any TWO of the following)

- Use of tap water. She should have used distilled water.
- Use of a beaker. She should have used a volumetric flask.
- Use of a glass rod to stir (as could transfer solute to rod). Mix by shaking the solution (in a sealed volumetric flask).
- She did not weigh the filter paper before and after transferring the solute to the beaker in order to ascertain (by subtraction) exactly how much solute was transferred. She should have done this (implied).

- She added the solute to 250 cm^3 of water, which would have resulted in a greater total volume than 250 cm^3. She should have added water to the solute to make up the total volume to 250 cm^3. (4)

5.1.3 sodium carbonate (Na_2CO_3) (1)

5.2 5.2.1 It is the point where an acid and base have reacted, so neither is in excess **OR** where **equivalent** (NOT same or equal) number of moles of acid and base have reacted. (2)

5.2.2 Colour: **Orange** since more HIn is formed.
Stress: Increase $[H_3O^+]$
Response: Favour reverse reaction
Reason: Reverse reaction uses up H_3O^+ or decreases $[H_3O^+]$ therefore relieves stress. (5)

5.3 5.3.1 $n = \frac{V}{V_m}$
$= 0,56 \div 22,4$
= 0,025 mol of CO_2 (OR **0,03 mol** to 2 dp) (2)

5.3.2 Mol ratio $HC\ell : CO_2$
2 : 1
0,05 : 0,025 (OR 0,06 : 0,03)

$V = \frac{n}{c}$
$= \frac{0,05}{0,25}$ $\frac{0,06}{0,25}$
V = 0,2 dm^3 of HCℓ **= 0,24 dm^3** (3)

5.4 5.4.1 $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$ Don't penalise single arrow.
Reactants/Products. (3)

5.4.2 GREATER THAN
Nitric acid is a **stronger** acid than ethanoic acid therefore it will **ionise more/produce more ions/donates H^+ more readily OR stronger** acids have higher K_a values. (3)

5.4.3 Nitric acid (c.o.e.) (Allow ethanoic acid if they have identified it as the stronger acid in Question 5.4.2.)
It would have a higher concentration of ions (more ions) as it is a stronger acid. (2)

5.4.4 **Ethanoic acid** (Allow HNO_3 if c.o.e. from Question 5.4.2.)
It is a weaker acid, therefore it would have a **lower concentration of H_3O^+ ions**.
$K_w = [H_3O^+] \bullet [OH^-]$ = constant OR $[OH^-]$ inversely proportional to $[H_3O^+]$
$\therefore$ if $[H_3O^+]$ is lower, then $[OH^-]$ must be higher. (3)

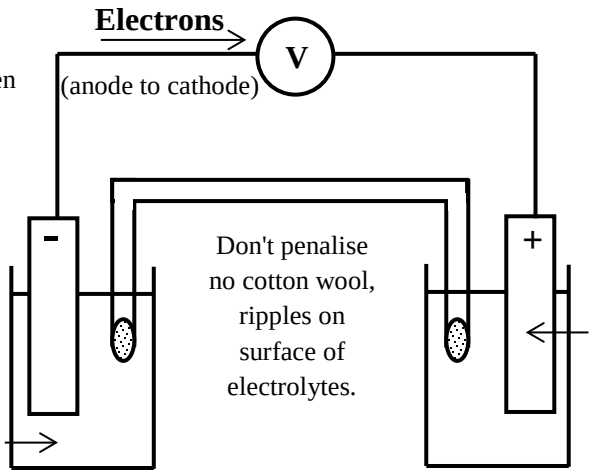
5.5 5.5.1 A salt is a substance in which the hydrogen **of an acid** has been replaced by a cation. (2)

5.5.2 pH=7,1 – 11 It is a **weak base/basic salt/salt of a strong base and a weak acid** as it causes an **increase in [OH^-].** (3)

5.5.3 $2CH_3COOH + Na_2O \longrightarrow 2CH_3COONa + H_2O$
Reactants/Products/Balanced (3)
[37]

QUESTION 6 GALVANIC CELLS

6.1



If identify Pb as cathode then coe for rest of diagram, $Cu(NO_3)_2$ as electrolyte in anode half-cell and electron from Cu to Pb

(Anode half-cell)

Allow any lead salt or Pb^{2+} solution.

Lead nitrate or $Pb(NO_3)_2(aq)$

Copper cathode

Diagram
Salt bridge
Electrodes in solutions
Voltmeter & wires
If show symbol for cell instead on voltmeter give max of 4/6 if rest of Q correct

(6)

6.2 $Pb(s)|Pb^{2+}$ (aq, 1 mol · dm^{-3})||Cu^{2+} (aq, 1 mol · dm^{-3})|Cu(s) at 25° C
Anode/Salt bridge/Cathode/Standard conditions (4)

State symbols not required.
NO c.o.e from 6.1

6.3 E^o cell = E^o cathode – E^o anode
= 0,34 – (–0,13)
= **0,47 V** (2)

NO c.o.e from 6.1

6.4 6.4.1 Completes circuit/allows ions through maintains electrical neutrality/ neutralises electrolyte/acts as an ion pump. (2)

6.4.2 As a result of **oxidation of the lead anode** the **concentration of positive lead ions** (cations) in the lead half-cell **increases** therefore the **negative** iodide ions move into the lead half-cell in order to maintain electrical neutrality (maintain balance between positive and negative ions). (3)

6.4.3 **Increases** emf. (1)

6.5 6.5.1 Increases (1)

6.5.2 No effect (1)
[20]

QUESTION 7 ELECTROLYTIC CELLS

7.1 Electrical energy to chemical (potential) energy. (1)

7.2 $A\ell^{3+} + 3e^- \longrightarrow A\ell$ (–1 per error) (2)

7.3 $2O^{2-} \longrightarrow O_2 + 4e^-$ (–1 per error) (2)
$C + 2O^{2-} \longrightarrow CO_2 + 4e^-$ (–1 per error)

} –1 in total for double arrows

7.4 The oxygen gas produced at the anode reacts with the graphite (carbon) to form carbon dioxide.
$C + O_2 \longrightarrow CO_2$ Reactants/Product (3)
$2A\ell_2O_3 + 3C \longrightarrow 3CO_2 + 4A\ell$

7.5 Less coal is burnt to produce electricity therefore fewer CO_2 (greenhouse gas) emissions OR conserving non-renewable fossil fuel OR less poisonous gas emissions (from burning coal to make electricity). (ONE reason only which **links to the environment**.) Do NOT accept reduces electricity/energy consumption without a link to the environment. (1)

7.6 Cryolite is **poisonous** or toxic fluoride (PFC) emissions (ONE reason only) (1)
Cryolite is mined which damages environment.

7.7 $A\ell^{3+}$ ions are a **weaker oxidising agent** (have a **more negative E^o**) than H_2O molecules, therefore H_2O will be reduced at the cathode in preference to $A\ell^{3+}$ ions.

$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$ (–1 per error) (4)

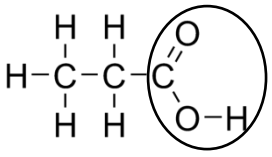
[14]

QUESTION 8 ORGANIC

8.1 8.1.1 A compound containing **only carbon and hydrogen** atoms in which there is at least one **double and/or triple bond** between **carbon** atoms. (3)

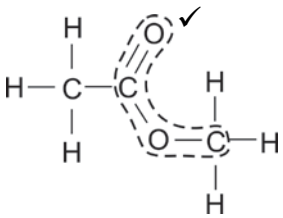
8.1.2 2-methylbut-2-ene **Mark allocation**: 2-methyl but -2- ene
The first 2- is redundant and need not be shown.
-1 if formatting error (gap between methyl and but- or no hyphens)) (4)

8.2 8.2.1 An atom or group of atoms that forms the centre of chemical activity in the molecule **OR** an atom or group of atoms that gives a compound its physical and chemical properties. (2)

8.2.2 

3 C's
Structure correct
Functional group correctly identified (3)

If give semi-structural or condensed structural formula –1 per question.
If give molecular formula then give 0

8.2.3 

Ethyl & methyl correct (3)

8.2.4 They have the **same molecular formula** (but different structural formulae**)** and **different functional groups/homologous series.** (3)

8.2.5 Methanol (1)

8.2.6 Ethyl methanoate (1)

8.2.7 Propanoic acid (1)

8.2.8
- Propanoic acid has **hydrogen bonds** between molecules.
- Methyl ethanoate has **dipole-dipole forces** between molecules.
- Hydrogen bonds are **stronger** than dipole-dipole forces.
- **More energy** needed to overcome the stronger intermolecular forces.

Do **NOT** give final mark if they say more energy …. to break **bonds.** (4)

8.3 8.3.1 (a) CH_3CH_3 or CH_3-CH_3 2C 6H (2)

(b) CH_3CH_2OH CH_3CH_2 OH (2)

Wrong format of formula -1 (structural or molecular)
Gap between CH_3 and CH_3 **-1**
(a) and (b) penalise each error once only

8.3.2 (a) chloroethane chloro ethane (2)

(b) ethene eth ene (2)

Don't penalise gap in name if already penalised in 8.1.2 (c.o.e.)
Don't penalise redundancy unless wrong eg take off a mark for 2-chloroethane and eth-2-ene

8.3.3 haloalkane (alkyl halide) (1)

8.3.4 alkene (1)

8.3.5 (a) substitution (free radical substitution/halogenation/chlorination) (1)

(b) substitution (hydrolysis) (1)

(c) elimination (dehydration) (1)

(d) addition (hydrogenation) (1)

(e) combustion (redox/oxidation) (1)

Mark first answer if more than one is given.

[40]

Total: 200 marks