NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION MARCH 2016

PHYSICAL SCIENCES: PAPER II

MARKING GUIDELINES

Time: 3 hours | 200 marks

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QUESTION 1 MULTIPLE CHOICE

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

[20]

QUESTION 2 BONDING, ENERGY CHANGE AND REACTION RATES

2.1 An intramolecular bond is one which occurs between atoms within molecules. (2)

2.2 2.2.1 polar covalent (2)

2.2.2 non-polar covalent (2)

2.3 An intermolecular force is a weak force of attraction between molecules or between atoms of noble gases. (2)

2.4 2.4.1 dipole-dipole forces (1)

2.4.2 induced dipole (London) forces (1)

2.5 2.5.1 Reaction rate is the change in concentration per unit time of either a reactant or a product. (2)

2.5.2 *Any one of the following:*

- Measure the volume of H_2 gas produced in a set time interval. Collect the gas in a gas syringe or in a gas jar using the downward displacement of water.
- Measure the loss in mass of the reaction mixture and the container over a set time interval. Place the reaction flask on a digital balance. (4)

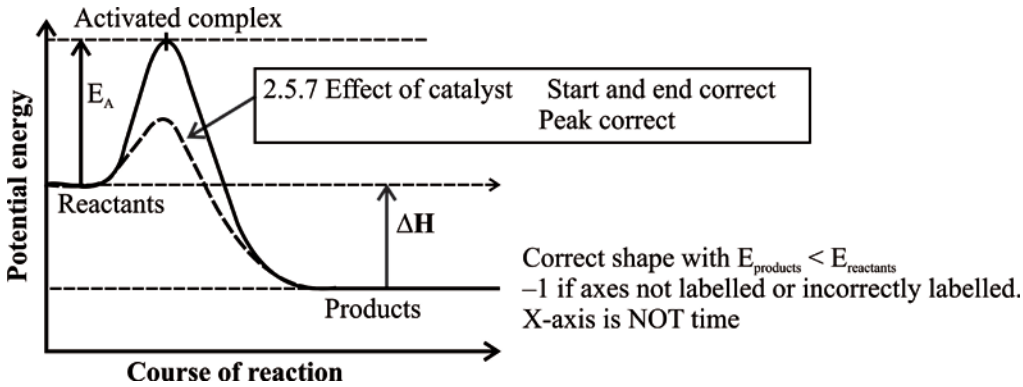
2.5.3 (a) $n = c \times V$
$= 0{,}25 \times 0{,}4$ (conversion)
= **0,1 mol of HCℓ** (3)

(b) $n = m/M$
$= \frac{4}{65{,}4}$
= 0,06 mol of Zn (2)

2.5.4 Mole ratio: Zn : HCℓ OR Zn : HCℓ
1 : 2 1 : 2
0,05 : 0,1 0,06 : 0,12

Therefore, **HCℓ is the limiting reagent** as there is **0,01 mol of Zn** in excess once all of the HCℓ has reacted or as an extra 0,02 mol of HCℓ is needed to react with all of the Zn. (3)

2.5.5



(6)

2.5.6 A catalyst is a substance that increases the rate of the reaction but remains unchanged at the end of the reaction. (2)

2.5.7 Refer to graph in Question 2.5.5 (2)

2.5.8 Powder has a greater surface area therefore there will be more effective collisions per unit time between the reactants (Zn and HCℓ). (3)

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QUESTION 3 CHEMICAL EQUILIBRIUM

3.1 Haber Process. (1)

3.2 3.2.1 As the pressure increases, the % yield of ammonia increases. (2)

3.2.2 As the temperature increases, the % yield of ammonia decreases. (2)

3.3 3.3.1 An increase in pressure **favours the forward reaction** which leads to the formation of **fewer moles of gas** which **relieves the stress of high pressure**. (3)

3.3.2 An increase in temperature **favours the reverse reaction** which is **endothermic**, therefore **absorbing the heat** and **relieving the stress of high temperature**. (3)

3.4 3.4.1 35% – 37% (1)

3.4.2 Pressure = 450 – 500 atmospheres ; temperature = 350 °C (2)

3.4.3 (a) Pressures higher than 200 atm are not used due to the **increased cost of the reinforced pipes** as well as **safety issues** associated with attaining such high pressures. (Factors relating to EITHER cost OR safety can be awarded 2 marks.) (2)

(b) A temperature of 450 °C is used to ensure a **faster reaction rate** . Yield is sacrificed for rate/'time is money' in industry. (2)

3.5 3.5.1 $K_c = \frac{[NH_3]^2}{[N_2].[H_2]^3}$ (2)

3.5.2 n = c × V
= 1,95 × 10
= 19,5 mols of N_2 present at equilibrium, therefore did NOT react
Thus, (20 – 19,5) = **0,5 mols** of nitrogen reacted (3)

3.5.3 $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Mole ratio *	**1**	**3**	**2**
moles at **Start**	**20**	**50**	0
moles **Used / formed**	(20 – 19,5) = 0,5	1,5	1,0
moles at **Equilibrium**	n=c.V = (1,95 × 10) = 19,5	(50 – 1,5) = 48,5	1,0
Conc. at equilibrium ($mol.dm^{-3}$) (c = n/V) (V = 2 dm^3)	**1,95**	4,85	0,1

Same mole ratio

Dividing by volume

NOTE: the 'circled' numbers were given in the question.

$K_c = \frac{[NH_3]^2}{[N_2].[H_2]^3}$

$K_c = \frac{[0,1]^2}{[1,95].[4,85]^3}$ (subst.)

$\mathbf{K_c = 4,50 \times 10^{-5}}$ (ans) (6)

3.5.4 The yield of ammonia at 450 °C would be very low. (1)

[30]

QUESTION 4 ACIDS AND BASES

4.1 A strong acid ionises almost completely in an aqueous solution, e.g. HY . A weak acid ionises partially in an aqueous solution, e.g. H_2X or HZ. (4)

4.2 A monoprotic acid is only able to donate one proton, e.g. HY or HZ. A polyprotic acid is able to donate more than one proton, e.g. H_2X. (4)

4.3 **HY** since it has the **highest K_a** which means it is the strongest acid and would have the **highest concentration of H_3O^+ ions**. (3)

4.4 **HZ** since it has the **lowest K_a** which means it ionises the least and would have the **lowest concentration of ions**. (3)

4.5 $H_2X + 2H_2O \leftrightarrows 2H_3O^+ + X^{2-}$ ions balanced
Or $H_2X + H_2O \leftrightarrows H_3O^+ + HX^-$ ions balanced (3)

4.6 4.6.1 $HZ + NaOH \rightarrow NaZ + H_2O$ (-1 per error) (3)

4.6.2 $n = c \times V$
$= 0,1 \times 0,0324$
$= 0,00324$ mol or $3,24 \times 10^{-3}$ mol (3)

4.6.3 $c = n/V$
$= \frac{0,00324}{0,025}$
$= 0,13$ mol.dm^{-3}

Alternative (not recommended but will be accepted)
$$\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B}$$
$$\frac{C_A \times 25,0}{0,1 \times 32,4} = \frac{1}{1}$$
C_A = **0,13 mol.dm^{-3}** (3)

4.6.4 **Greater than 7.**
Na^+ and OH^- would form the **strong base NaOH which remains fully dissociated**.
H^+ (H_3O^+) and Z^- would form the **weak acid HX which is not fully ionised**.
Thus **H^+ (H_3O^+) ions are removed from the solution** (favouring forward reaction for ionisation of water) leading to an **excess of OH^- ions** (therefore basic, pH>7). (5)

4.6.5 (a) Phenolphthalein (1)

(b) The indicator will change to the end-point or equivalence point colour over the pH range given, therefore the final pH of the solution (in this case >7) must fall within the pH range of the indicator. (2)

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QUESTION 5 GALVANIC CELL

5.1 The anode is the electrode where oxidation takes place. (2)

5.2 Metal X since it is corroding (oxidising). (2)

5.3 Concentration of electrolytes = 1 mol.dm^{-3} and temperature = 25 °C (298 K) (2)

5.4 $E^o_{cell} = E^o_{cathode} - E^o_{anode}$
$0,46 = -0,28 - E^o_X$ (c.o.e. from 5.2)
$E^o_X = -0,74$ V Therefore electrode X is chromium (Cr) (4)

5.5 5.5.1 $Cr \rightarrow Cr^{3+} + 3e^-$ or $X \rightarrow X^{3+} + 3e^-$ (c.o.e. from 5.4) (2)

5.5.2 $Co^{2+} + 2e^- \rightarrow Co$ (2)

5.5.3 $2Cr + 3Co^{2+} \rightarrow 2Cr^{3+} + 3Co$ (2)

–1 in total for use of double arrows –1 per error for each equation

5.6 A reducing agent is a substance that donates electrons. (2)

5.7 Cr (2)

[20]

QUESTION 6 ELECTROLYSIS

6.1 Electrical to chemical (2)

6.2 $Ag^+ + e^- \rightarrow Ag$ (–1 per error) (2)

6.3 The **copper impurities are oxidised**.
The gold impurities are **not oxidised**; they will fall to the bottom of the cell where they form a sludge.
Cu is a stronger reducing agent than Ag, and Au is a weaker reducing agent than Ag.
(Cu has a less positive E° (0,34 V) and Au has a more positive E° (1,42 V) than silver (0,8 V) (which is the potential difference applied across the terminals of the battery).) (4)

6.4 The Cu^{2+} ions are weaker oxidising agents than Ag^+ ions therefore Cu^{2+} ions will not be reduced at the cathode. (2)

6.5 $n = m / M$
$= \frac{5,83}{108}$
= 0,054 mol of Ag therefore 0,054 mol of electrons transferred ($Ag^+ + e^- \rightarrow Ag$)

$Q = n \times F$
$= 0,054 \times 96\ 500$
$= 5\ 211$ C

Alternative
$Q = 0,054 \times 6,02 \times 10^{23} \times 1,6 \times 10^{-19}$
$= 5201,28$ C

$I = Q/t$
$= \frac{5\ 211}{(30 \times 60)}$ conversion
(I = 2,89 A)

I = 2,895 A (2,90 A) (7)

[17]

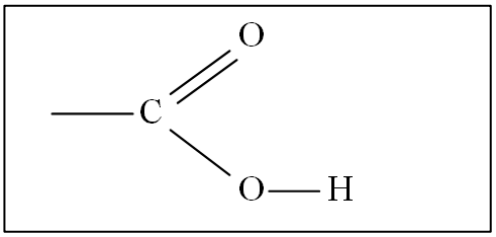
QUESTION 7 ORGANIC

7.1 7.1.1 A homologous series is a series of similar compounds which have the **same functional group** and have the **same general formula**, in which **each member differs from the previous one by a single CH_2 unit**. (3)

7.1.2 A functional group is **an atom or a group of atoms** that form the **centre of chemical activity** in the molecule (responsible for the chemical properties of that molecule). (2)

7.2 7.2.1 carboxylic acids (1)

7.2.2



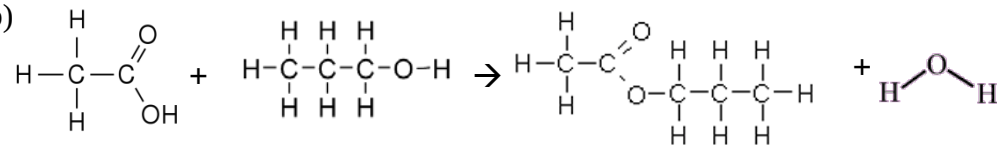
Carbonyl group correct
Hydroxyl group correct
–COOH = max of 1 mark

(2)

7.2.3 ethanoic acid eth anoic acid (2)

7.2.4 (a) esterification (or substitution or condensation) (1)

(b)



(5)

(c) propyl ethanoate (2)

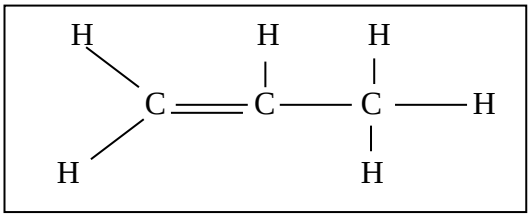
(d) pentanoic acid (2)

(e) Use a **water bath** (place reaction vessel in a 'bath' of warm water) or use a heating mantle. Alcohols are flammable. OR Organic compounds (especially esters) are volatile and their fumes are flammable. OR It is not safe due to risk of fire. (3)

7.3 7.3.1 elimination (1)

7.3.2 C_8H_{18} 8C 18H (2)

7.3.3



Correct number of Cs & Hs.
All bonds shown correctly.
If shows correct molecular or condensed structural formula, give 1 mark.

(2)

7.3.4 Various options possible.
Correct carbon chain. (8 Cs with at least one branch.)
Hydrogens correct.
If shows correct condensed structural formula, give 1 mark. (2)

7.3.5 $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ Products both reactants balanced
Allow c.o.e. for molecular formula of octane from Question 7.3.2. (4)

7.3.6 Mix each reactant separately with bromine water.
Compound Z (propene) will rapidly decolourise the bromine water.
Octane will have little/no effect on the bromine water. (3)

7.3.7 **Compound Y ($C_{11}H_{24}$)** will have the higher boiling point.
Compound Y and octane both have **London (induced dipole) forces** between their molecules.
Compound Y has a **longer chain** therefore **more electrons** and a **greater contact surface area**, therefore **temporary dipoles** are set up more easily (in more places) (at least two of the points in **bold**.)
This leads to the formation of more London forces which collectively are **stronger** than those found between the molecules of octane.
More energy is needed to break the stronger intermolecular forces. (5)
[42]

Total: 200 marks

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