NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2017

PHYSICAL SCIENCES: PAPER II

MARKING GUIDELINES

Time: 3 hours | 200 marks

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QUESTION 1 MULTIPLE CHOICE

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

[20]

QUESTION 2 CHEMICAL BONDING AND QUANTITATIVE CHEMISTRY

2.1 2.1.1 Ne (1)

2.1.2 N_2 (1)

2.1.3 diamond (1)

2.1.4 NH_3 (1)

2.1.5 NaCℓ (1)

2.1.6 NH_3 (1)

2.1.7 N_2 or diamond (1)

2.2 2.2.1 MnO_4^- (1)

2.2.2 $Mg(C\ell O_3)_2$ ($C\ell O_3$) formula (2)

2.3 Water has **hydrogen bonding forces** between its molecules, which are **stronger** than the weak **dipole-dipole forces** between the molecules of hydrogen sulphide. **More energy** is needed to overcome the forces between the water molecules in order to keep it in the gas phase. (4)

2.4 2.4.1 Water OR H_2O (1)

2.4.2 Ion-dipole force (2)

2.4.3 $Mg(NO_3)_2(s) \rightarrow Mg^{2+}(aq) + 2NO_3^{2-}(aq)$ Mg^{2+}; $2NO_3^-$; phase indicators (4)

2.4.4 n = c.V
= 0,15 × 0,2 (conversion)
= 0,03 mol of $Mg(NO_3)_2$
n = 2 × 0,03 = **0,06 mol of NO_3^-** (3)

2.4.5 n = c.V
= 0,5 × 0,2
= 0,1 mol of NO_3^- ions in total

n = (0,1 – 0,06) = 0,04 mol of NO_3^- ions added
(0,06 c.o.e. from Question 2.4.5)

m = n × M
= 0,04 × 85
= **3,4 g of $NaNO_3$** (5)

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QUESTION 3 ENERGY CHANGE AND REACTION RATES

3.1 3.1.1 (a) The net change of chemical potential energy of the system. (2)

(b) A temporary transition state between the reactants and the products. (2)

3.1.2 Endothermic. (1)

3.1.3 (a) 20 kJ (1)

(b) 165 kJ (1)

(c) – 30 kJ (2)

(d) (90 – 20) = 70 kJ (subtraction does not need to be shown) (2)

3.2 3.2.1 All of the hydrochloric acid (limiting reagent) has reacted (been used up).
OR The reactants have been used up.
OR The reaction has stopped. (2)

3.2.2 (a) Graph **D**. (1)
(b) Graph **C**. (1)
(c) Graph **B**. (1)

3.2.3 Graph **B** represents experiment 4 where there are **more molecules of H_2SO_4 with the correct orientation per unit volume** therefore **more effective collisions per unit time** and a **faster reaction rate** as shown by the steeper gradient. The final volume of hydrogen produced in experiment 4 (graph B) is greater than in experiment 1 (graph A) since the **number of moles of H_2SO_4 reacting with the excess zinc is greater**. (4)

3.2.4 $n = \frac{V}{V_m}$

$= \frac{0,056}{22,4}$ (conversion)

$= 0,0025$ mol

$\text{Rate} = \frac{0,0025}{25}$

$= 0,0001$ mol of H_2 per second (4)

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QUESTION 4 CHEMICAL EQUILIBRIUM

4.1 4.1.1 When an external stress is applied to a system in chemical equilibrium, the equilibrium point will change in such a way as to counteract the stress. (3)

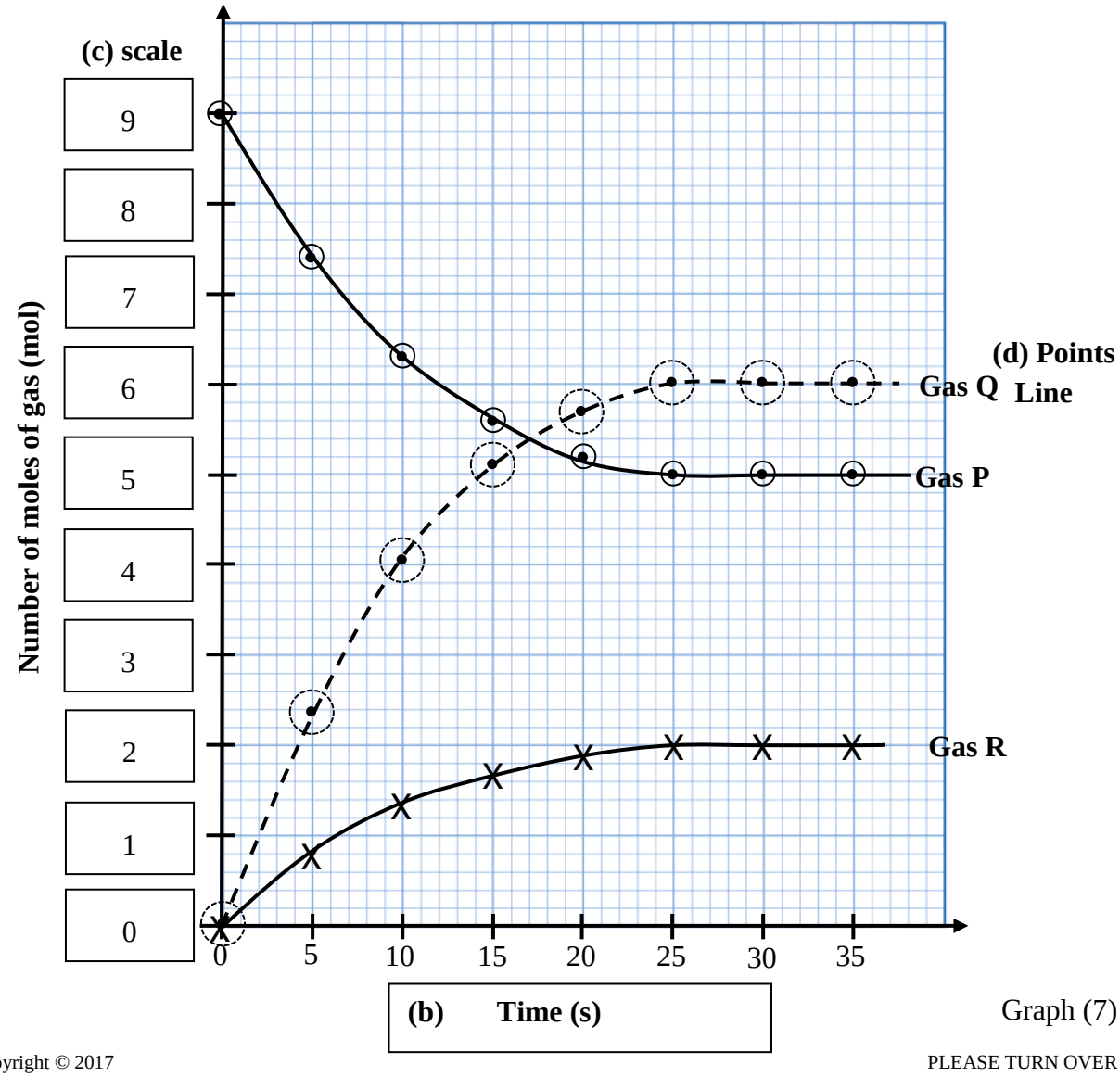
4.1.2 A measure of the extent of a reaction, generally measured by comparing the amount of product against the amount of product that is possible. (2)

4.1.3 Decrease volume of container. This will increase the pressure, which will favour the **forward reaction**, which produces **less moles** of gas and therefore **relieves the stress** of high pressure.
– If they say increase volume (decrease pressure) then no marks for explanation.
– Give mark for correct inverse relationship between volume and pressure. (5)

4.2 4.2.1 (a) Dynamic chemical equilibrium is reached when the rate of (formation of the products in) the forward reaction is equal to the rate of (formation of the reactants in) the reverse reaction. (1)

(b) There is **no change in the number of moles** (and hence concentration) of any of the gases after 25 s as shown by the data. (1)

4.2.2 **(a)** Graph to show the number of moles of gases (P, Q and R) with time
OR Graph of number of moles of gas vs time



Graph (7)

4.2.3 **2** P ⇌ **3** Q + **1** R (Accept: 4P ⇌ 6Q + 2R) (3)

4.2.4 $K_c = \frac{[Q]^3.[R]}{[P]^2}$ c.o.e. from Question 4.2.3 (2)

4.2.5 $K_c = \frac{\left[\frac{6}{5}\right]^3 \cdot \left[\frac{2}{5}\right]}{\left[\frac{5}{5}\right]^2}$

Marks n_P = 5 mol c.o.e. from Question 4.2.4
n_Q = 6 mol
n_R = 2 mol
Divide by volume (5 dm^3)

K_c = 0,69

OR

$K_c = \frac{(1,2)^3 \cdot (0,4)}{(1)^2}$

K_c = 0,69 (5)

4.2.6 **Low** yield c.o.e. from Question 4.2.5 (1)

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QUESTION 5 ACIDS AND BASES

5.1 5.1.1 An acid is a proton donor. (1)

5.1.2 A strong acid is one that ionises almost completely in an aqueous solution. (2)

5.1.3 He has **diluted** the acid but it is still a strong acid as it will still (almost) fully ionise. (3)

5.1.4 $HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$ (use of single or double arrow accepted)
Reactants Products Balanced (3)

5.1.5 $2\ HNO_3 + MgO \rightarrow Mg(NO_3)_2 + H_2O$ Reactants
Products
Balanced (3)

5.1.6 Magnesium nitrate (If formula $Mg(NO_3)_2$ is given, then give 1 mark only) (2)

5.2 n = c.V
= 0,2 × 0,5
= 0,1 mol HCℓ (added to impure sample)

n = c.V
= 0,3 × 0,04
= 0,012 mol NaOH
∴ 0,012 mol of excess HCℓ

mol ratio	NaOH : HCℓ
	1 : 1
	0,012 : 0,012

n = (0,1 – 0,012) = 0,088 mol of HCℓ reacted with Na_2CO_3

mol ratio	Na_2CO_3 : HCℓ
	1 : 2
	0,044 : 0,088

m = n × M
= 0,044 × 106
= **4,66 g of Na_2CO_3 in original sample** (8)
[22]

QUESTION 6 GALVANIC CELLS

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

6.2 Nickel since it has gained mass reduction has taken place here. (2)

6.3 $Ni^{2+} + 2e^- \rightarrow Ni$ (–1 per error; single arrow) (No c.o.e. from Question 6.2) (2)

6.4 $E°_{cell} = E°_{cathode} – E°_{anode}$

0,93 = –0,25 – E°x

E°x = –1,18 V

Therefore, metal X = **Mn** (manganese) (4)

6.5 $Mn/Mn^{2+}//Ni^{2+}/Ni$ OR $X/X^{2+}//Ni^{2+}/Ni$ anode salt bridge cathode (3)

6.6 6.6.1 A concentrated solution is more conductive, therefore, it **lowers the internal resistance** and **increase the ability of the cell to deliver current**. (2)

6.6.2 The **balance between positive and negative ions in the solution** is maintained so that overall the solution is neutral (uncharged). (1)

6.6.3 K^+ ions are a weak(er) oxidising agent (than Ni^{2+} ions) therefore, they will not be reduced at the cathode.
Fe^{3+} ions are a strong(er) oxidising agent (than Ni^{2+} ions) therefore they will be reduced at the cathode.
OR
In the anode half-cell Fe^{3+} ions are a stronger oxidising agent than Mn^{2+} ions, therefore Fe^{3+} ions will be reduced by Mn, which will oxidise. (4)
[20]

QUESTION 7 ELECTROLYTIC CELLS

7.1 Electrical energy to chemical energy. (1)

7.2 Asbestos (1)

7.3 7.3.1 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ (–1 per error) (2)

7.3.2 $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (–1 per error) (2)

7.3.3 $2C\ell^- + 2H_2O \rightarrow C\ell_2 + H_2 + 2OH^-$ (–1 per error) (2)

–1 in total for double arrows

7.4 7.4.1 Purification of water
Bleach
Making PVC
Making hydrochloric acid
Making insecticides (1)

7.4.2 Making nylon
Hardening of margarine and oils
Making NH_3 to make fertiliser (1)

7.5 $C\ell^-$ (2)

7.6 7.6.1 The asbestos diaphragm is **non-selective** therefore $C\ell^-$ ions as well as Na^+ ions pass through into the cathode compartment. The membrane in the membrane cell is **selective to Na^+ ions** only and will not allow $C\ell^-$ ions through. (3)

7.6.2 **Two different reasons:**

- The asbestos diaphragm is toxic (causes cancer). (The membrane is not toxic.)
- The membrane cell is cheaper to run/lower operating costs/consumes less energy.
- The membrane cell is cheaper to set up/lower capital costs. (2)

[17]

QUESTION 8 ORGANIC CHEMISTRY

8.1 8.1.1 E (1)

8.1.2 B (1)

8.1.3 C (1)

8.2 8.2.1 Ethene eth ene (2)

8.2.2 1,2-dichloroethane 1,2 dichloroethane (2)

8.3 Haloalkane (alkyl halide) (1)

8.4 C_nH_{2n+2} (1)

8.5 8.5.1 $NaC\ell$ (1)

8.5.2 H_2O (1)

8.6 $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$ reactants products balanced (3)

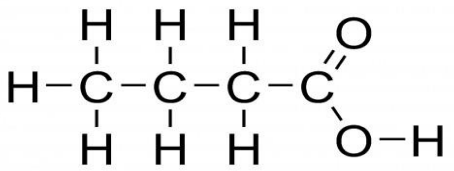
8.7 Dehydrating agent/catalyst (2)

8.8 Use a water bath/place liquid in test tube and place test tube in beaker of hot water. OR Use an electric heating mantle. (2)

8.9 8.9.1 Substitution (hydrolysis) (1)

8.9.2 Addition (halogenation/chlorination) (1)

8.10 8.10.1

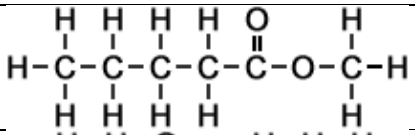
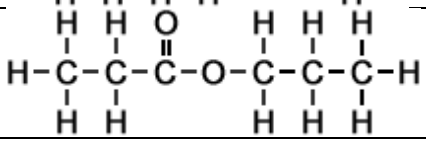
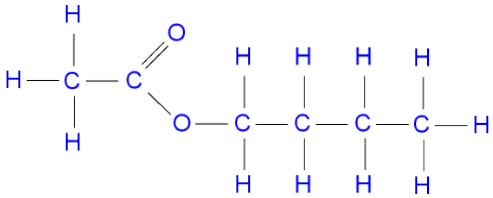
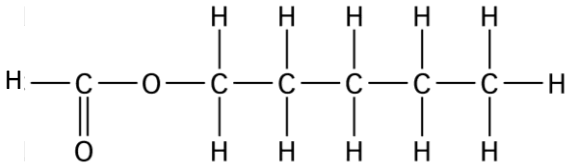


4C's carboxyl group (2)

8.10.2 $C_6H_{12}O_2$ (–1 per error) (2)

8.10.3 hexanoic acid hex anoic acid (2)

8.10.4 ONE of the positional isomers shown in the table below.
Name: 1 mark per part alkyl alkanoate
Formula: 1 mark for correct formula of ester linkage one mark for rest correct
(–1 if give condensed structural formula; 0 if give molecular formula)
(Mark the name independently of the formula.)

Name	Structural formula
Methyl pentanoate	
Propyl propanoate	
Butyl ethanoate	
Pentyl methanoate	

(4)

8.11 **London forces** between molecules of compound **E** are **NOT of the same strength** (weaker) as the hydrogen bonds between water molecules. Hence compound **E** will not dissolve in water.
Hydrogen bonds between the molecules of compound **B** and water are of **similar strength** hence they will dissolve in each other. (4)

8.12 Both ethane and butane have **London forces** between their molecules. The London forces between the molecules of butane are **stronger** and require **more energy** to be overcome.
Reasons for stronger London forces in butane (must give ONE of the following)
Butane has larger molecules therefore **more electrons** (greater electron density) therefore **temporary dipoles set up more easily**.
Butane has a **longer carbon chain** (therefore greater contact surface area) therefore **more places to set up temporary dipoles**. (4)
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Total: 200 marks

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