NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION MARCH 2016

PHYSICAL SCIENCES: PAPER II

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 13 pages and a green Data Sheet of 3 pages (i – iii).
2. Please make sure that your question paper is complete.
3. Remove the Data Sheet from the middle of this question paper.
4. Read the questions carefully.
5. ALL of the questions in this paper must be answered.
6. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice for the correct answer must be marked with a cross as shown in the example below:

A	**B**	**C**	**D**

Here the answer C has been marked as correct.

7. **START EACH QUESTION ON A NEW PAGE.**
8. Please ensure that you number your answers as the questions are numbered.
9. Use the data and formulae whenever necessary.
10. Show all of the necessary steps in calculations.
11. Where appropriate, take your final answers to 2 decimal places, unless instructed otherwise.
12. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple-choice Answer Sheet inside the front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

1.1 Metallic bonding is defined as ...

A the unequal sharing of electrons between metal atoms leading to the formation of a dipole.
B a transfer of electrons between metal atoms and subsequent electrostatic attraction.
C the attraction between a positive metal kernel and a sea of delocalised electrons.
D a weak force of attraction between metal atoms.

1.2 The correct chemical formula for calcium hydrogen carbonate is ...

A $Ca(HCO_3)_2$.
B CaH_2CO_3.
C Ca_2HCO_3.
D $CaHCO_3$.

1.3 A weak base is defined as one which ...

A ionises almost completely in an aqueous solution.
B ionises partially in an aqueous solution.
C dissociates almost completely in an aqueous solution.
D dissociates partially in an aqueous solution.

1.4 A hypothetical reaction in a closed container, represented by the balanced chemical equation below, is in a state of dynamic chemical equilibrium:

$$A(g) + B_2(g) \rightleftharpoons B_2A(g) \qquad \Delta H > 0$$

The volume of the container is increased leading to a decrease in pressure whilst keeping the temperature constant. How does this affect the rate of the reverse reaction and the yield of B_2A?

	Rate of reverse reaction	**Yield of B_2A**
A	Increases	Increases
B	Increases	Decreases
C	Decreases	Increases
D	Decreases	Decreases

1.5 1 mole of $PC\ell_5$ gas is heated in a closed container. 50% of the $PC\ell_5$ gas decomposes to set up the equilibrium represented by the balanced chemical equation below.

$$PC\ell_5(g) \rightleftharpoons PC\ell_3(g) + C\ell_2(g)$$

How many moles of gas are present in the container at equilibrium?

A 0,5
B 1,0
C 1,5
D 2,0

1.6 Which of the factors given below are conditions necessary for chemical equilibrium to be established?

(i) A closed system
(ii) A constant temperature
(iii) Equal concentrations of reactants and products

(A) (i) and (ii) only
(B) (i), (ii) and (iii)
(C) (i) and (iii) only
(D) (i) only

1.7 The balanced chemical equation for the spontaneous redox reaction of chlorine gas with an aqueous solution of potassium bromide is given below.

$$C\ell_2(g) + 2KBr(aq) \longrightarrow 2KC\ell(aq) + Br_2(aq)$$

Which one of the following gives the formula of the oxidising agent and the reducing agent of this reaction?

	Oxidising agent	**Reducing agent**
A	$C\ell_2$	Br_2
B	$C\ell_2$	Br^-
C	K^+	Br_2
D	K^+	Br^-

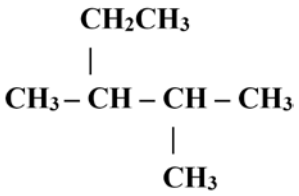
1.8 Which one of the following redox reactions is non-spontaneous under standard conditions?

A $Fe(s) + Sn^{2+}(aq) \longrightarrow Fe^{2+}(aq) + Sn(s)$
B $Cd^{2+}(aq) + Zn(s) \longrightarrow Cd(s) + Zn^{2+}(aq)$
C $Ni(s) + Mn^{2+}(aq) \longrightarrow Ni^{2+}(aq) + Mn(s)$
D $Pb^{2+}(aq) + Co(s) \longrightarrow Pb(s) + Co^{2+}(aq)$

1.9 Which one of the following organic compounds is an unsaturated hydrocarbon?

A C_2H_6
B C_3H_6
C CH_3COOH
D CH_4

1.10 The IUPAC name of the organic compound given below is:



A 2-ethyl-3-methylbutane
B 3-ethyl-2-methylbutane
C 2-ethyl-1,1-dimethylpropane
D 2,3-dimethylpentane

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QUESTION 2 BONDING, ENERGY CHANGE AND REACTION RATES

2.1 Define an *intramolecular bond.* (2)

2.2 Name the **specific** type of intramolecular bond found in:

2.2.1 Hydrogen chloride gas (HCℓ (g)) (2)

2.2.2 Hydrogen gas (H_2(g)) (2)

2.3 Define an *intermolecular force.* (2)

2.4 Name the **specific** type of intermolecular force found in:

2.4.1 Hydrogen chloride gas (HCℓ (g)) (1)

2.4.2 Hydrogen gas (H_2(g)) (1)

2.5 Experiments are conducted to determine factors influencing the rate of reaction between 400 cm^3 of 0,25 $mol.dm^{-3}$ hydrochloric acid and 4 g of zinc granules. They react according to the following balanced chemical equation:

$$Zn(s) + 2HC\ell(aq) \longrightarrow ZnC\ell_2(aq) + H_2(g) \qquad \Delta H < 0$$

2.5.1 Define *reaction rate.* (2)

2.5.2 Suggest one method (experimental technique) to measure the rate of the reaction above. Make reference to the apparatus one would use. (4)

2.5.3 Calculate the number of moles of:

(a) HCℓ in 400 cm^3 of 0,25 $mol.dm^{-3}$ HCℓ solution (3)

(b) Zn in 4 g of Zn granules (2)

2.5.4 Determine which reactant is the limiting reagent in the reaction above and state how many moles of the other reactant is in **excess**. Show all calculations in support of your answer. (3)

2.5.5 Draw a potential energy profile graph to represent the reaction above. Supply suitable labels for the axes as well as the following:

- Energy of reactants
- Energy of products
- Activated complex
- Activation energy (E_A)
- Heat of reaction (ΔH) (6)

2.5.6 Define a *catalyst.* (2)

2.5.7 Using a broken line (– – – – –), show on your graph you drew in Question 2.5.5, the effect of the catalyst on this reaction. (2)

2.5.8 Use collision theory to explain the effect on the reaction rate when using powdered zinc instead of zinc granules. The mass of the zinc powder and the zinc granules remains constant. (3)

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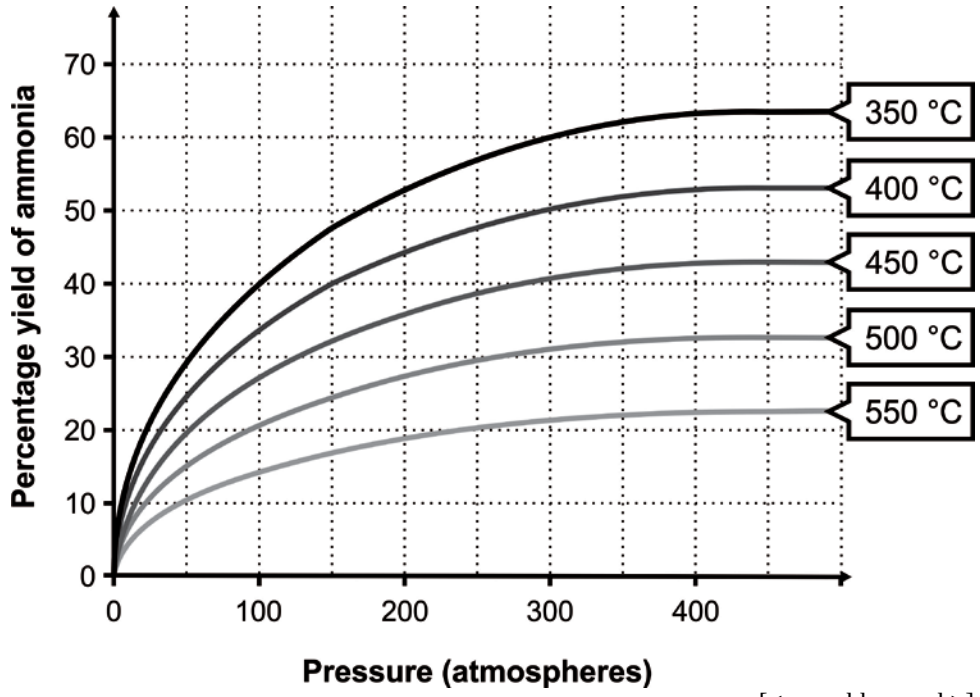
QUESTION 3 CHEMICAL EQUILIBRIUM

Ammonia is prepared on a large scale in industry by the reaction of hydrogen gas and nitrogen gas in a closed container according to the following balanced chemical equation:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

The graph below shows how the percentage yield of ammonia varies with changes in pressure and temperature.



[<www.bbc.co.uk>]

3.1 State the name given to the industrial preparation of ammonia. (1)

3.2 Use the graph to determine the relationship between:

3.2.1 pressure and percentage yield of ammonia. (2)

3.2.2 temperature and percentage yield of ammonia. (2)

3.3 Use Le Chatelier's Principle to **EXPLAIN** the relationship in Question 3.2 between percentage yield of ammonia and …

3.3.1 pressure. (3)

3.3.2 temperature. (3)

3.4 The typical conditions used in industry for the large scale production of ammonia are a pressure of 200 atmospheres and a temperature of 450 °C.

3.4.1 Use the graph to determine the percentage yield of ammonia under these conditions. (1)

3.4.2 Use the graph to state what conditions of pressure and temperature would give a yield of ammonia of approximately 64%. (2)

3.4.3 Consider your answers to Questions 3.4.1 and 3.4.2 and suggest why the industrial process is carried out at a …

(a) pressure of 200 atmosphere. (2)

(b) temperature of 450 °C. (2)

3.5 A scientist introduces 20 moles of N_2 gas and 50 moles of H_2 gas into a container of volume 10 dm^3. The container is sealed and the gases react and reach equilibrium at 450 °C according to the following balanced chemical equation:

$$\mathbf{N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0}$$

At equilibrium, the concentration of nitrogen gas is 1,95 $mol.dm^{-3}$.

3.5.1 Write down the expression for the equilibrium constant (K_c) for this reaction. (2)

3.5.2 Calculate the number of moles of nitrogen gas which reacted. (3)

3.5.3 Calculate the equilibrium constant, K_c, for this reaction at 450 °C. (6)

3.5.4 State what information your answer for K_c indicates about the yield of ammonia at 450 °C. (1)

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QUESTION 4 ACIDS AND BASES

The acid ionisation constant K_a for the ionisation of each of the hypothetical acids H_2X, HY and HZ in water at 25 °C is given in the table below.

Acid	K_a
H_2X	$2{,}8 \times 10^{-3}$
HY	$1{,}2 \times 10^{6}$
HZ	6×10^{-4}

4.1 State the difference between a strong acid and a weak acid. Give one example of each. (Choose from H_2X, HY or HZ.) (4)

4.2 State the difference between a monoprotic and a polyprotic acid. Give one example of each. (Choose from H_2X, HY or HZ.) (4)

4.3 Which acid, H_2X, HY or HZ, has the lowest pH in water? Justify your choice. Assume that the concentration of each acid is the same. (3)

4.4 Which acid, H_2X, HY or HZ, is the weakest electrical conductor in water? Justify your choice. Assume that the concentration of each acid is the same. (3)

4.5 Write down a balanced chemical equation to represent the ionisation of acid H_2X in water. Symbols for the phases need not be shown. (3)

4.6 25,0 cm^3 of acid HZ is neutralised in a titration by 32,4 cm^3 of 0,1 $mol.dm^{-3}$ NaOH solution. An aqueous solution of the salt NaZ is produced in the reaction.

4.6.1 Write down a balanced chemical equation for the reaction of HZ with NaOH. (The phase of each substance is not required.) (3)

4.6.2 Calculate the number of moles of NaOH which reacted. Give your answer correct to 5 decimal places (or 3 significant figures). (3)

4.6.3 Calculate the concentration of acid HZ. (3)

4.6.4 Consider the equations given below for the dissociation of NaZ in water and for the ionisation of water.

$$NaZ(s) \rightleftharpoons Na^+(aq) + Z^-(aq)$$
$$H_2O(\ell) \rightleftharpoons OH^-(aq) + H^+(aq)$$

Consider the interaction between the ions in the aqueous solution of the salt NaZ and hence predict whether the solution would have a pH of LESS THAN 7, EQUAL TO 7, OR GREATER THAN 7. Explain your answer fully. (5)

4.6.5 The indicators given in the table below are available for the titration.

INDICATOR	pH RANGE OF INDICATOR
bromothymol blue	6,0 – 7,6
phenolphthalein	8,4 – 10,0
methyl orange	3,1 – 4,4

(a) Select an indicator from the table which would be most suitable for the titration of HZ with NaOH in Question 4.6. (1)

(b) Briefly justify your choice of indicator with reference to your understanding of what is meant by the 'pH range of the indicator'. (2)

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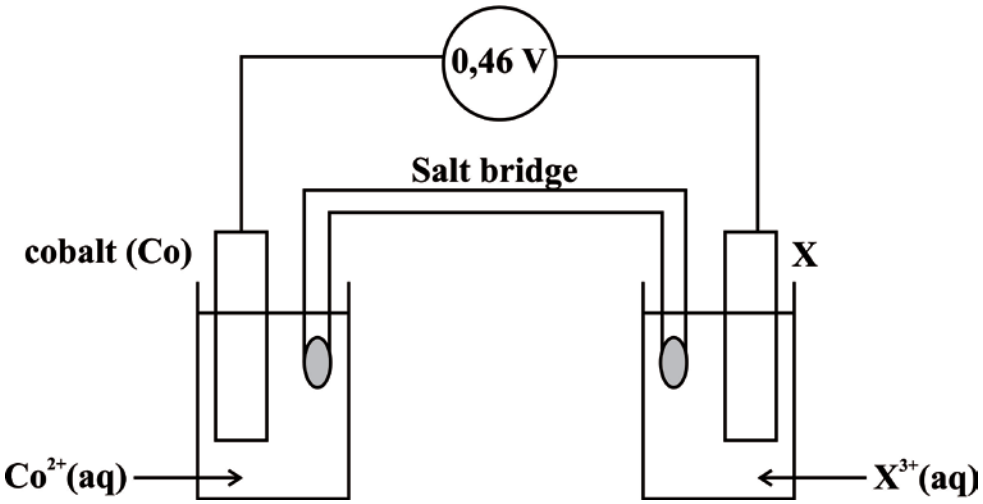
QUESTION 5 GALVANIC CELL

A galvanic cell is set up under standard conditions using cobalt and an unknown metal X as electrodes, as shown in the diagram below. The voltmeter reads 0,46 V. After the cell had been operating for a period of time, evidence of corrosion was observed on electrode X.



5.1 Define an *anode*. (2)

5.2 Which electrode, cobalt or metal X, is the anode? Justify your choice. (2)

5.3 State the standard conditions that apply to this cell. (2)

5.4 Calculate the standard electrode potential of the $X|X^{3+}$ half-cell and hence identify metal X. (4)

5.5 Write down the balanced chemical equation for each of the following reactions taking place in this cell:

5.5.1 Anode half-reaction (2)

5.5.2 Cathode half-reaction (2)

5.5.3 Net cell reaction (2)

5.6 Define *reducing agent*. (2)

5.7 Give the **symbol** of the reducing agent in this cell. (2)

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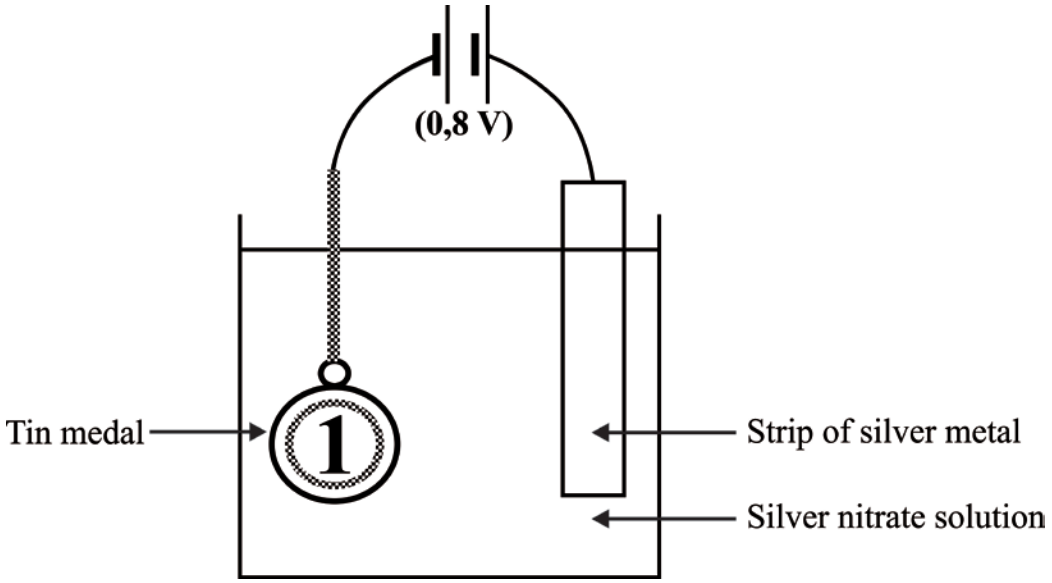
QUESTION 6 ELECTROLYSIS

Jonas wants to electroplate his old tin medal with silver. He connects his medal to the negative terminal of a battery and he connects a strip of silver metal to the positive terminal of the battery. The electrodes are then immersed in a solution of silver nitrate ($AgNO_3$). A voltage of 0,80 V is maintained across the terminals of the battery. The diagram below represents the simple electrolytic cell that he used.



6.1 State the energy conversion that takes place in this cell. (2)

6.2 Write down a balanced chemical equation for the half-reaction taking place on the surface of the medal. (2)

6.3 The strip of silver metal contains traces of copper and gold impurities. With reference to the relative strengths of the reducing agents involved, clearly explain what happens to the copper and gold impurities in the silver strip. (4)

6.4 With reference to the relative strengths of the oxidising agents involved, explain why none of the copper impurities are transferred to the medal. (2)

6.5 It is found that, after passing a constant current through the cell for 30 minutes, the mass of silver deposited on the medal is 5,83 g. Calculate the strength of the constant current that was used. (7)

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QUESTION 7 ORGANIC

7.1 Define the terms:

7.1.1 *Homologous series.* (3)

7.1.2 *Functional group.* (2)

7.2 The condensed structural formula for a compound X is **CH_3COOH**.

7.2.1 Name the homologous series to which compound **X** belongs. (1)

7.2.2 Draw the structural formula of the functional group of compound **X**. (2)

7.2.3 Give the IUPAC name of compound **X**. (2)

7.2.4 Compound **X** reacts with propan-1-ol when heated gently in the presence of a few drops of concentrated sulphuric acid.

(a) State what type of reaction takes place between compound **X** and propan-1-ol. (1)

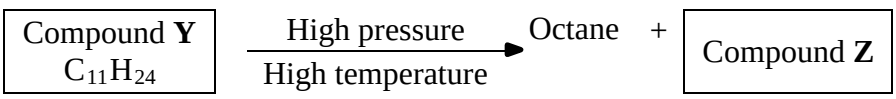
(b) Write down a balanced chemical equation using **structural formulae** for this reaction. (It is not necessary to show phase indicators.) (5)

(c) Give the IUPAC name of the organic product formed in this reaction. (2)

(d) Give the IUPAC name of a **functional** isomer of the product formed in this reaction. (2)

(e) Suggest a method that should be used to heat this reaction mixture and state WHY this method should be used. (3)

7.3 The chemical equation for the cracking of a compound **Y** which has the molecular formula, $C_{11}H_{24}$, is given below. Compound **Y** is a hydrocarbon with an unbranched chain.



7.3.1 Name the type of reaction of which cracking is an example. (1)

7.3.2 Give the molecular formula for octane. (2)

7.3.3 Draw the structural formula of compound **Z**. (2)

7.3.4 Draw the structural formula of a chain isomer of octane. (2)

7.3.5 Write down a balanced chemical equation, using molecular formulae, for the complete combustion of octane. (It is not necessary to show phase indicators.) (4)

7.3.6 Describe a chemical test which would distinguish between octane and compound **Z**. (3)

7.3.7 Predict which substance, compound **Y** ($C_{11}H_{24}$) or octane, will have the higher boiling point. Justify your choice by making reference to the relevant intermolecular forces and the factors influencing their strength. (5)

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Total: 200 marks