



NATIONAL SENIOR CERTIFICATE EXAMINATION
EXEMPLAR PAPER 2014

CHEMISTRY

Time:

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages.
 2. Please check that your question paper is complete.
 3. ALL the questions in this paper must be answered.
 4. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. Write only the letter of the correct answer.
 5. **START EACH QUESTION ON A NEW PAGE.**
 6. Read the questions carefully.
 7. Use the data and formulae whenever necessary.
 8. Express ALL answers correct to TWO decimal places.
 9. An approved calculator (non-programmable, non-graphical) may be used.
 10. Show all the necessary steps in calculations.
 11. It is in your own interest to write legibly and to set your work out neatly.
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QUESTION 1 MULTIPLE CHOICE

- 1.1 The table below lists three properties of solids. Which one of solids A – D has its particular properties listed correctly? (2)

SOLIDS	PROPERTIES OF SOLIDS		
	Forces holding solid together	Electrical conductivity	Melting point (relative)
A Diamond	Covalent bonds	Good conductor	Very high
B Sodium chloride	Electrostatic forces	Good conductor	High
C Candle wax	London Forces/ Dispersion forces	Non-conductor	Relatively low
D Dry ice (solid carbon dioxide)	Dipole-dipole Forces	Non-conductor	low

(2)

- 1.2 Which one of the following lists correctly places the species in **increasing** order of reducing ability?

- A Al Ni²⁺ Cu Cl⁻
 B Al Cu Ag Cl⁻
 C H₂O Ni²⁺ Pb²⁺ Cu²⁺
 D Ag Cu Fe Mg

(2)

- 1.3 The cell potential of a standard galvanic cell in which an aluminium half cell is connected to a standard half cell containing metal X as the electrode, is 1,53 V.

Which one of the metals given below will represent metal?

- A Pb
 B Sn
 C Au
 D Ni

(2)

- 1.4 The correct IUPAC name for $\text{CH}_2 - \text{CH}_2 - \underset{\text{CH}_3}{\overset{\text{CH}_2 - \text{CH}_3}{\text{C}}} = \text{C} - \text{CH}_3$ is

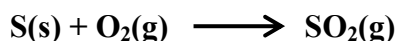
- A 2,3-diethylbut-2-ene
 B 2-ethyl-3-methylpent-2-ene
 C 4-ethyl-3-methylpent-3-ene
 D 3,4-dimethylhex-3-ene

(2)

- 1.5 Which one of the following organic molecular conversions is an example of an addition reaction? (2)

A ethanol $\rightarrow$ chloroethane
B ethene $\rightarrow$ ethane
C propanol $\rightarrow$ propene
D ethanol $\rightarrow$ ethylethanoate

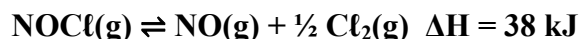
- 1.6 64 g of sulphur undergoes complete combustion in excess oxygen, according to the following equation:



What volume of SO_2 gas (at STP), in dm^3 , will be produced by this reaction?

A 2 dm^3
B $11,2 \text{ dm}^3$
C $44,8 \text{ dm}^3$
D 64 dm^3 (2)

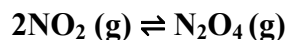
- 1.7 Nitrosyl chloride (NOCl) is able to thermally decompose according to the following equation:



If the activation energy for the forward reaction is 100 kJ, what will be the activation energy for the **reverse** reaction in kJ?

A 38
B 62
C 100
D 138 (2)

- 1.8 The equilibrium constant for the reaction given below is 8,81 at 200°C .



If the equilibrium concentration of NO_2 is $0,200 \text{ mol}\cdot\text{dm}^{-3}$ what is the concentration of N_2O_4 in $\text{mol}\cdot\text{dm}^{-3}$ at this temperature?

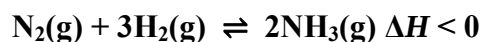
A $3,52 \times 10^{-1}$
B $2,27 \times 10^{-2}$
C 1,76
D $4,53 \times 10^{-3}$ (2)

- 1.9 Sulphuric acid ionises completely in water to produce a solution of concentration $0,05 \text{ mol.dm}^{-3}$. Assuming that the sulphuric acid ionises completely, what will be the concentration of hydroxide ions $[\text{OH}^-]$ in the solution of sulphuric acid?

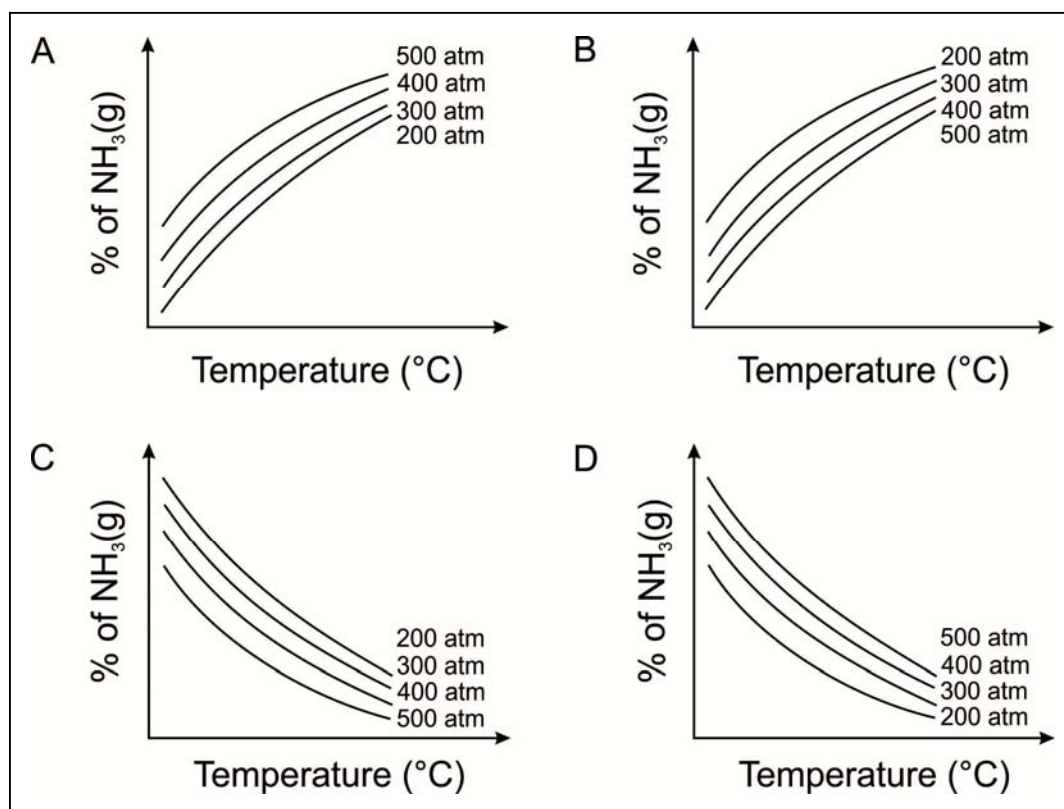
- A $5,00 \times 10^{-16} \text{ mol.dm}^{-3}$
B $1,00 \times 10^{-13} \text{ mol.dm}^{-3}$
C $2,00 \times 10^{-13} \text{ mol.dm}^{-3}$
D $1,00 \times 10^{-15} \text{ mol.dm}^{-3}$

(2)

- 1.10 Consider the following equilibrium system:



Which of the following graphs shows the effect of temperature and pressure on the percentage of $\text{NH}_3(\text{g})$ in the equilibrium mixture?

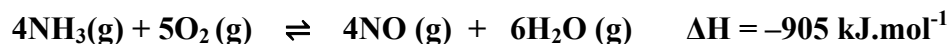


[Ref: <<http://home.sbc.edu.hk/~chem>>]

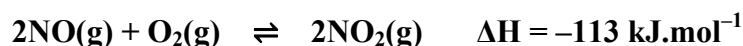
(2)
[20]

QUESTION 2

- 2.1 The first stage in the Ostwald process used in the manufacture of nitric acid involves the catalytic oxidation of ammonia. A platinum alloy is used as a catalyst.



- 2.1.1 Explain what is meant by the term '*catalyst*'. (2)
- 2.1.2 The platinum alloy catalyst needs to be heated up at the start of the process. Suggest the most likely reason for this. (2)
- 2.1.3 Why does the platinum catalyst remain hot during the process without needing further heating? (2)
- 2.1.4 This reaction is carried out at a relatively low pressures between 1 and 2 atmospheres. Explain why lower pressures are desirable as a means to increase the amount of product formed in this reaction. (3)
- 2.2 The second stage of the Ostwald process takes place in a closed container and is shown by the equation below:

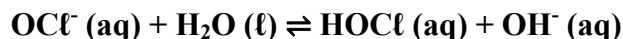


- 2.2.1 What change in temperature should be made to obtain as high a yield of NO_2 as possible? **Explain your answer.** (4)
- 2.2.2 The above equilibrium is set up in the laboratory by injecting 20,83 moles of NO and 12 moles of O_2 into a $2,5 \text{ dm}^3$ sealed container at a given temperature. At equilibrium it is found that 18 moles of NO_2 are present.
- (a) Write an expression for the equilibrium constant for this reaction. (2)
- (b) Calculate the value of K_c for this reaction at this temperature. (5)
- (c) Referring to the value of the equilibrium constant calculated in part (b) above, what can be concluded about the yield of NO_2 in this reaction under these conditions. (2)
- (d) What would the effect on K_c be if an extra 12 moles of O_2 was added to the equilibrium mixture described above. (2)

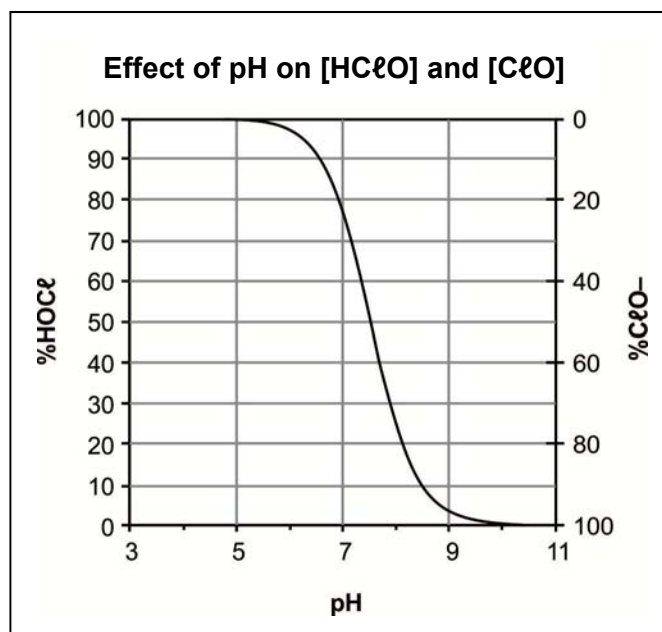
[24]

QUESTION 3

In a swimming pool, calcium hypochlorite $\text{Ca}(\text{OCl})_2$ dissociates in water to release the hypochlorite anion $\text{OCl}^-(\text{aq})$ which establishes the following dynamic chemical equilibrium in solution:

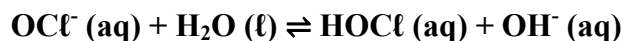


- 3.1 Explain what is meant by the term '*dynamic chemical equilibrium*'. (3)
- 3.2 The above equilibrium is highly pH dependent as can be seen from the graph below:



[Ref: <<http://www.dougdelamatter.com/website1/science/chemistry/pool/pool1.pdf>>]

Refer to the above graph and the equilibrium equation below, to answer the questions which follow:



- 3.2.1 Using the graph, which pH (low or high) favours the formation of HOCl? (1)
- 3.2.2 Over which pH range is the concentration of HOCl **most** sensitive to changes in pH? (2)
- 3.2.3 Using the fact that $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 10^{-14}$, and with reference to the equation and relevant equilibrium principles, explain why a lower pH favours the production of HOCl. (5)
- 3.2.4 Why do you think it would not be a good idea to make the pH in swimming pool as low as 3 or 4? (2)

3.3 Hydrochloric acid (HCl) is used in swimming pools to control the pH levels in the pool. This acid also has the ability to react with the pool pipes which contain iron.

3.3.1 Give a balanced chemical equation for a possible reaction that could occur when hydrochloric acid (HCl) in the pool reacts with iron pipes. (3)

3.3.2 A student is asked to investigate how temperature affects rate of reaction between iron and hydrochloric acid in the laboratory. The student uses iron filings and hydrochloric acid of concentration 1 mol.dm^{-3} .

(a) Describe one possible experimental set-up suitable for investigating the reaction rate in this experiment ensuring that your answer refers to **what the student should measure AND what apparatus should be used to measure it.** A sketch may be used to aid explanation. (4)

(b) Making reference to collision theory, describe how increasing temperature is expected to affect rate of reaction. (3)

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QUESTION 4

- 4.1 Sulphuric acid is a very important industrial chemical used in the manufacture of car batteries, fertilisers and pharmaceuticals as well as in many other applications. Sulphuric acid is a *strong, diprotic acid*.

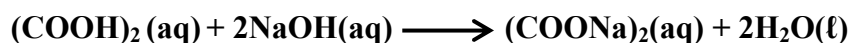
4.1.1 Define the term '**strong acid**'. (2)

4.1.2 Write a balanced chemical equation showing the **complete** ionisation of sulphuric acid in water. (2)

4.1.3 Solution A is H_2SO_4 of concentration $0,2 \text{ mol.dm}^{-3}$
Solution B is HNO_3 of concentration $0,2 \text{ mol.dm}^{-3}$

Which solution (A or B) would you expect to have the greater electrical conductivity? **Explain your answer.** (3)

- 4.2 Oxalic acid $(\text{COOH})_2$ is used in a titration to neutralise sodium hydroxide solution (NaOH). The balanced chemical equation for the reaction is as follows:



During the titration, 25 cm^3 of a standard solution of oxalic acid, of concentration $0,05 \text{ mol.dm}^{-3}$ is measured into a flask using a burette. Sodium hydroxide of unknown concentration is added to the flask swirling constantly, until the end point (equivalence point) is reached. The titration is repeated three times and the volume of sodium hydroxide recorded in the table below each time. (Refer to the balanced chemical equation given in 4.2 above.)

Volume oxalic acid (cm^3)	Volume sodium hydroxide at end point (cm^3)
25	21,0
25	21,4
25	20,9

4.2.1 Comment on the precision of the results shown in the table above. (2)

4.2.2 Explain what is meant by the term 'standard solution'. (2)

4.2.3 Using the results in the table:

(a) calculate the average volume of sodium hydroxide used. (1)

(b) calculate the concentration of the sodium hydroxide solution (**Give your answer correct to 3 decimal places.**) (5)

- 4.2.4 Using the following table, choose a suitable indicator for the titration of the oxalic acid with sodium hydroxide solution and briefly justify your choice of indicator.

Indicator	pH Range
Phenolphthalein	8,2 – 10
Bromothymol Blue	6,0 – 7,6
Methyl Orange	3,2 – 4,4

(4)

- 4.2.5 The sodium hydroxide solution was initially prepared by dissolving 1,40 g of what the students believed to be pure sodium hydroxide in a volumetric flask and making the solution up to 250 cm^3 , using distilled water. Calculate the concentration of the sodium hydroxide (**Give your answer correct to 3 decimal places.**)



(4)

- 4.2.6 The students performing this titration are puzzled by the difference between the concentration calculated and the concentration determined from the titration in 4.2.3 (b). They read on the internet that solid sodium hydroxide is **deliquescent**, meaning that it is able to absorb water from the surrounding atmosphere. This is especially problematic in humid environments.

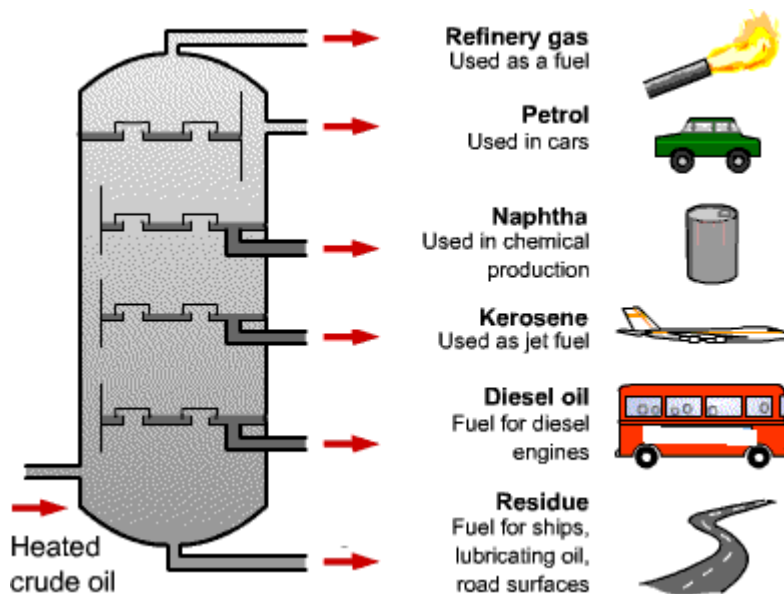
Use this fact to briefly explain the discrepancy in results making reference to a suitable formula.

(3)

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QUESTION 5

Crude oil is separated into fractions by fractional distillation. The sketch alongside shows the fractionating column for fractional distillation of crude oil. Crude oil is heated to around 400 °C – 500 °C and enters the column at the bottom. As the vapour rises, it cools and the fractions condense at different levels.



[Ref: <<http://www.cyberphysics.co.uk/topics/energy/oil.htm>>]

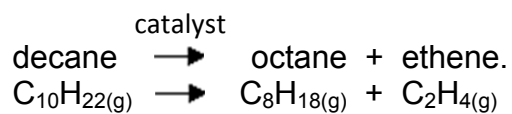
Study the table below and answer the questions which follow:

Fraction	No of carbon atoms	Boiling Point Range (°C)
Refinery Gas	3 – 4	Below 30
Petrol	7 – 9	100 – 150
Naphtha	6 – 11	70 – 200
Kerosene	11 – 18	200 – 300
Diesel	11 – 20	200 – 300
Fuel Oil, Greases and Waxes and Bitumen	>20	>300

Crude oil is a mixture of alkanes with different molecular masses.

- 5.1 Give the general formula of the homologous series **alkanes**. (2)
- 5.2 Define the term **homologous series**. (2)
- 5.3 Name the type of intermolecular forces that exist between alkane molecules and **explain briefly how these forces occur**. (4)
- 5.4 Explain in detail why the boiling point of the alkanes increases as the number of carbon atoms increases. (3)
- 5.5 Which fuel, diesel or petrol will have a higher **viscosity**? (1)

- 5.6 Naptha components are often cracked due to the high demand for lighter fractions for use as petrol in cars. The following reaction is an example of a cracking reaction where decane is cracked using a catalyst.



C_2H_4 is an **unsaturated** hydrocarbon.

- 5.6.1 Explain what is meant by the term '**unsaturated**'. (2)

- 5.6.2 C_2H_4 undergoes hydration in the presence of steam. Write a balanced chemical equation for the hydration of ethene (C_2H_4). (3)

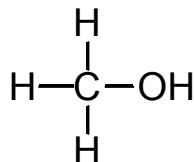
- 5.6.3 What type of reaction is represented by the hydration of ethene? (1)

[18]

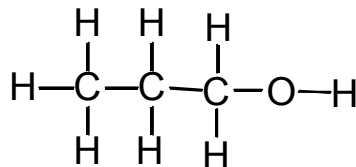
QUESTION 6

Refer to compounds A to E, along with their boiling points shown below:

Compound A (BPt. 66 °C)



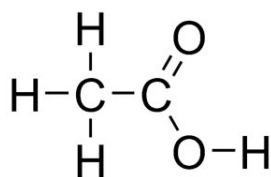
Compound B (BPt. 97 °C)



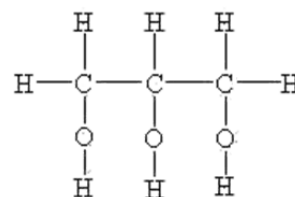
Compound C (BPt. 195 °C)



Compound D (BPt. 118 °C)



Compound E (BPt. 290 °C)



All the compounds represented by A to E belong to one of two homologous series.

- 6.1 Name the **two homologous series** represented above in A to E **and using only the letters**, identify which compounds belong to which homologous series. (4)
- 6.2 Consider compound D.
 - 6.2.1 Name compound D (2)
 - 6.2.2 Compound D is an example of a **functional isomer**.
 - (a) Explain what is meant by a **functional isomer**. (2)
 - (b) Give the full structural formula and name of a functional isomer of compound D. (3)
- 6.3 Name the type of intermolecular forces occurring between molecules of compound B. (1)
- 6.4 Compound A is a liquid at room temperature. A similar one-carbon compound, methane, is a gas at room temperature. Explain why these similar compounds are found in different phases at room temperature. (4)
- 6.5 Compound A burns in excess oxygen and can be used as a fuel in cars. Write a balanced equation for the combustion of compound A in excess oxygen. (3)
- 6.6 Compounds A, B, C, D and E are all miscible (mix fully) with water while compound C is not. Give a possible explanation as to why this occurs. (3)

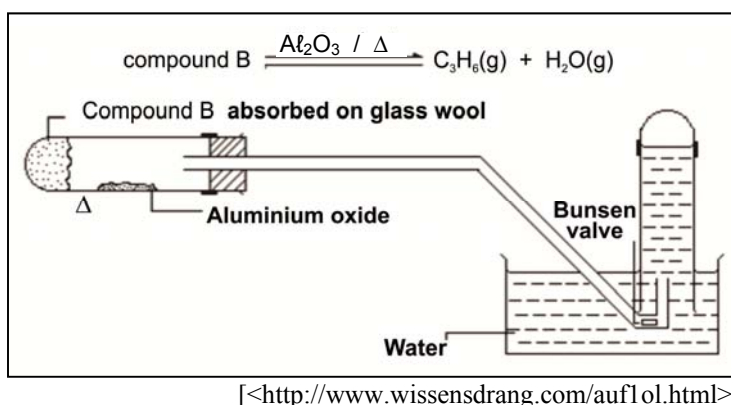
6.7 Two of the compounds shown react together to form a compound called propyl ethanoate, with the distinctive smell of pears.

6.7.1 Draw the full structural formula for propyl ethanoate. (3)

6.7.2 Draw the functional group **and** the name of the homologous series to which propyl ethanoate belongs. (2)

6.8 Give the IUPAC name compound B. (2)

6.9 **Compound B is shown undergoing a chemical reaction below:**



6.9.1 Identify the type of reaction occurring above. (1)

6.9.2 The product C_3H_6 can undergo a catalysed addition reaction with hydrogen gas. Name the product of this addition reaction. (2)

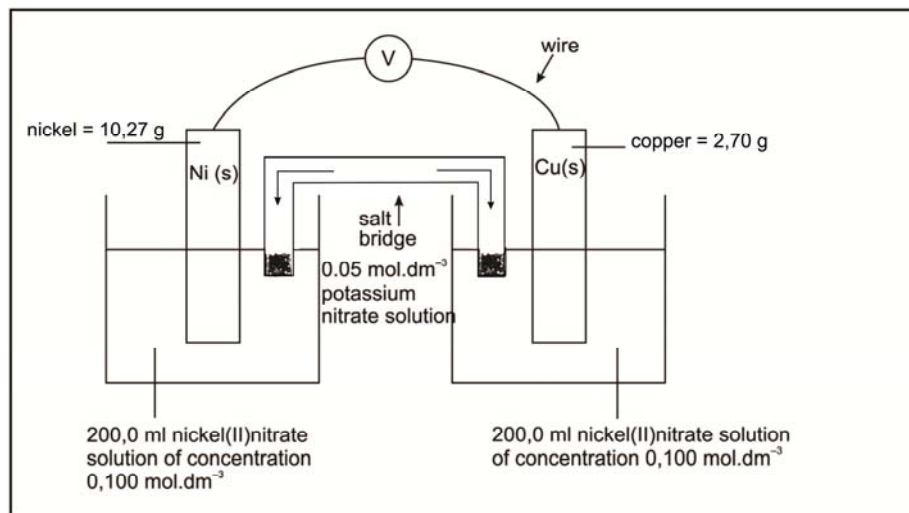
[32]

QUESTION 7

Consider the galvanic cell as shown in the diagram below. The temperature in the room in which the galvanic cell is constructed is 20°C . The masses of the electrodes at the start, before the cell is connected are:

nickel electrode = 10,27 g

copper electrode = 2,70 g



[Ref: Adapted from 2011 HSC Examination Chemistry]

- 7.1 Define the term **oxidation**. (2)
- 7.2 Which electrode will act as the anode in this cell? Using electrochemical principles explain your answer. (4)
- 7.3 Describe the function of the salt bridge in this cell. (3)
- 7.4 Is the above cell a standard cell? Explain your answer fully. (3)
- 7.5 Calculate the mass of nickel(II)nitrate that needs to be used to prepare the electrolyte with concentration $0,100 \text{ mol.dm}^{-3}$. (4)
- 7.6 After a period of time, a solid deposit that had formed on the copper electrode was removed and dried. The deposit has a mass of 0,395 g.
 - 7.6.1 Calculate the final mass of the **nickel** electrode. (4)
 - 7.6.2 If that the time taken for 0,395 g of copper to be deposited is 40 minutes, calculate the current flowing in the wire.
(The Faraday constant is given as 96485 C.mol^{-1}) (6)

[26]

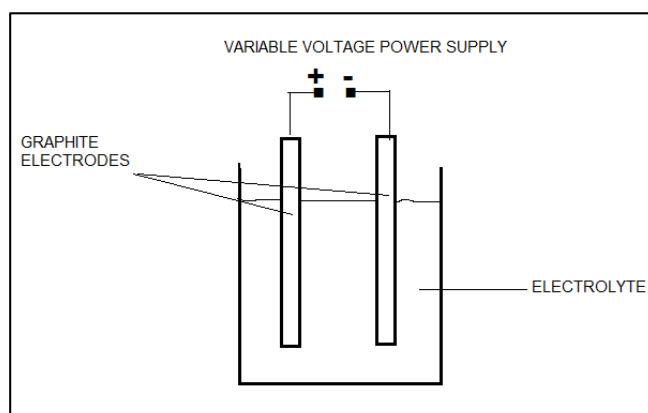
QUESTION 8

- 8.1 Two learners decide to perform an experiment to investigate how the potential difference supplied across the electrodes in an electrolytic cell affects the rate of metal deposition. They decide to measure the mass of copper deposited in 2,5 hours for different potential differences.

They set up the cell as shown below and their results are shown in the table alongside. They use copper(II)chloride as the electrolyte and graphite rods as the electrodes.

Table showing results of experiment to investigate how potential difference across cell affects rate of metal deposition.

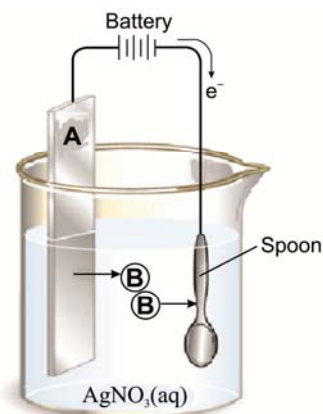
Potential Difference (V)	Electrode Mass (g)		
	Initial	Final (after 2,5 hours)	Change
1,5	6,50	6,90	0,40
3,0	6,50	7,33	0,83
4,5	6,51	7,75	1,24
6,0	6,57	8,20	1,63



[Adapted from the Chemical Industries Resource Pack . 2010. University of Capetown]

- 8.1.1 List **three variables** which they should keep constant during their experiment. (3)
- 8.1.2 What is the independent variable in the investigation. (2)
- 8.1.3 Using the data in the table, plot a graph showing the results of the experiment. (7)
- 8.1.4 Describe the shape of the graph you have drawn. (1)
- 8.1.5 Use the graph to write a conclusion for their experiment. (2)

- 8.2 The diagram below shows the electrochemical cell for electroplating a spoon with silver.



[<<http://www.ustudy.in/node/3220>>]

- 8.2.1 Describe the energy change taking place in the cell. (2)
- 8.2.2 Of what metal must electrode A consist in this electrolytic cell? (1)
- 8.2.3 Give an equation for the half reaction occurring at electrode A (2)
- 8.2.4 Is the **spoon** a cathode or an anode? (1)
- 8.2.5 Suppose a student in the laboratory mistakenly prepared the electrolyte sodium nitrate (NaNO_3) instead of silver nitrate (AgNO_3) for use in the above process. Having connected the electrodes to the power supply, the student notices some bubbles forming on one of the electrodes.
- At which electrode (A or the spoon) will bubbles be observed? (1)
 - Identify the gas formed which bubbles off the electrode. (1)
 - Explain why this gas is formed instead of a metal forming. **Also give a relevant half reaction.** (4)
- 8.3 Give another industrial use for electrolysis other than electroplating. (2)

[29]

Total: 200 marks