MARKER CODE

Student Personal Identification Number

South Pacific Form Seven Certificate

CHEMISTRY

2014

QUESTION and ANSWER BOOKLET

Time allowed: Two and a half hours

INSTRUCTIONS

Write your **Student Personal Identification Number (SPIN)** in the space provided on the top right hand corner of this page.

Answer **ALL QUESTIONS**. Write your answers in the spaces provided in this booklet.

If you need more space for answers, ask the Supervisor for extra paper. Write your SPIN on all extra sheets used and clearly number the questions. Attach the extra sheets at the appropriate places in this booklet.

Major Learning Outcomes (Achievement Standards)	Skill Level			Weight /Time
	Band 1 *Basic*	Band 2 *Proficient*	Band 3 *Advanced*	
CheA: Interpret information about selected properties of elements and compounds in relation to atomic structure	11 questions	3 questions	1 question	20% 46 min
CheB: Use thermochemcial data to determine energy changes in chemical and physical processes	3 questions	1 question	1 question	8% 20 min
CheC: Relate the properties of aqueous solutions to the nature and concentration of dissolved species	3 questions	1 question	1 question	8% 20 min
CheD: Apply oxidation-reduction principles to electrochemical cells and compare the relative strength of oxidants	4 questions	1 question	1 question	9% 20 min
CheE: Use information about the structure and reactions of organic molecules to solve problems in organic chemistry	12 questions	2 questions	1 question	19% 44 min
TOTAL	**33 questions**	**8 questions**	**5 questions**	**65% 150 min**

Check that this booklet contains pages 2-15 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

CheA: Atomic Structure and Bonding and Related Principles

Interpret information about selected properties of elements and compounds in relation to atomic structure.

Assessor's use only

A1a Write the electron arrangement, using *s, p, d* notation, for the following:

Cl ______________________________

Fe^{3+} ______________________________

Basic	Level
Excellent	
Weak	
NR	

A2a Explain why Cl^{-} ions are bigger than Cl atoms.

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Basic	Level
Excellent	
Weak	
NR	

A2b Explain why even though Cl^{-} ions and K^{+} ions have the same electron configuration, Cl^{-} ions are bigger than K^{+} ions.

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Basic	Level
Excellent	
Weak	
NR	

A3a Rank the following atoms in **decreasing** order of ionisation energy

F, Cl and S ______________________________

Justify your answer with reference to the electron configurations of the atoms.

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Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

Assessor's use only

A4a Draw the Lewis structure for the following:

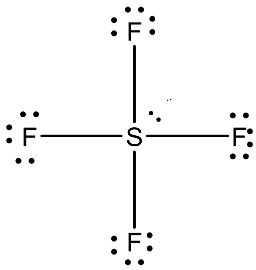
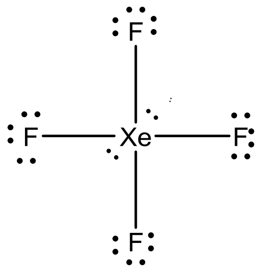
IF_5	PCl_4^+

Basic	Level
Excellent	
Weak	
NR	

The Lewis structures of two molecules that both have the formula AX_4 are given in the table below.

A4b (i) Name the shape of each molecule.

A4c (ii) Draw a sketch (using wedge and dash notation) for each molecule.

	SF_4	XeF_4
Lewis structure		
Name of shape		
Sketch of Shape		

Basic	Level
Excellent	
Weak	
NR	

Basic	Level
Excellent	
Weak	
NR	

A4d Explain why the shapes in (ii) above are different.

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Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

	Water molecules, H_2O, and carbon dioxide molecules, CO_2, both contain polar bonds. Water molecules are bent and carbon dioxide molecules are straight (linear).	
A5a	Explain why the bonds in both molecules are polar. __________ __________ __________	**Basic** | **Level** Excellent Weak NR
A5b	Explain why the water molecule is polar but the carbon dioxide molecule is not. __________ __________ __________ __________	**Proficient** | **Level** Excellent Moderate Weak NR
	Methanol. CH_3OH, and oxygen, O_2 have the same molar mass (32 g mol^{-1}). However, methanol has a much higher boiling point than oxygen.	
A6a	Describe all the intermolecular forces between: the molecules of O_2 __________ __________ the molecules of CH_3OH __________ __________	**Basic** | **Level** Excellent Weak NR
A6b	Explain why CH_3OH has a higher boiling point than O_2 __________ __________ __________ __________ __________ __________	**Proficient** | **Level** Excellent Moderate Weak NR
A7a	Write a balanced equation for the following nuclear reaction. Naturally occurring thorium-232 (^{232}Th) undergoing *α* decay: $^{232}Th \rightarrow$ ______ + ______	**Basic** | **Level** Excellent Weak NR

Assessor's use only

A7b	Sr-90 decays by β emission. It has a half life of 29 years. A sample of Sr-90 has a decay rate of 1.2 x 10^{12} disintegrations per second. Calculate the decay rate of this sample after 116 years? ____ ____	**Basic** / **Level** Excellent Weak NR
A7c	Some countries generate their electricity using nuclear reactors. This process involves nuclear fission reactions. However, many countries are co-operating to develop nuclear fusion reactors as these will provide a more efficient method of energy production. Explain what is meant by the terms: nuclear fission ___________________________________ ____ nuclear fusion ____________________________________ ____	**Basic** / **Level** Excellent Weak NR
A8a	When ammonia is added to a solution of copper sulfate a pale precipitate initially forms. On the addition of excess ammonia the precipitate dissolves and a deep blue solution forms. Complete the following equations for this reaction sequence. $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow$ ____________ $+ 6H_2O$ $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow$ ____________ $+ 6H_2O$	**Basic** / **Level** Excellent Weak NR

CheB: Energy Changes and Physical Processes

Use thermochemical data to determine energy changes in chemical and physical processes.

Assessor's use only

B1a Butanol, $C_4H_{10}O$ can be synthesised from cellulose and is a useful fuel as it is less toxic than more traditional fuels such as methanol.

Write the equation for which the energy change is the enthalpy of formation, $\Delta_f H$, of butanol.

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Basic	Level
Excellent	
Weak	
NR	

B1b Pentaborane reacts in excess oxygen as follows:

$$2B_2H_{9(g)} + 12O_{2(g)} \rightarrow 5B_2O_{3(s)} + 9H_2O_{(g)}$$

Calculate the enthalpy of the reaction using the following enthalpies of formation:

$\Delta_f H(B_2H_{9(g)}) = 73.0 \text{ kJ mol}^{-1}$

$\Delta_f H(B_2O_{3(s)}) = -1273 \text{ kJ mol}^{-1}$

$\Delta_f H(H_2O_{(g)}) = -242 \text{ kJ mol}^{-1}$

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Basic	Level
Excellent	
Weak	
NR	

Basic	Level
Excellent	
Weak	
NR	

B2a Calculate the standard enthalpy of formation for diborane, B_2H_6, using the equations given below. The equation for the reaction is:

$$2B_{(s)} + 3H_{2(g)} \rightarrow B_2H_{6(g)}$$

$4B_{(s)} + 3O_{2(g)} \rightarrow 2B_2O_{3(s)}$	$\Delta_r H^\circ = -2509 \text{ kJ mol}^{-1}$
$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(\ell)}$	$\Delta_r H^\circ = -572 \text{ kJ mol}^{-1}$
$B_2H_{6(g)} + 3O_{2(g)} \rightarrow B_2O_{3(s)} + 3H_2O_{(\ell)}$	$\Delta_r H^\circ = -2148 \text{ kJ mol}^{-1}$

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Proficient	Level
Excellent	
Moderate	
Weak	
NR	

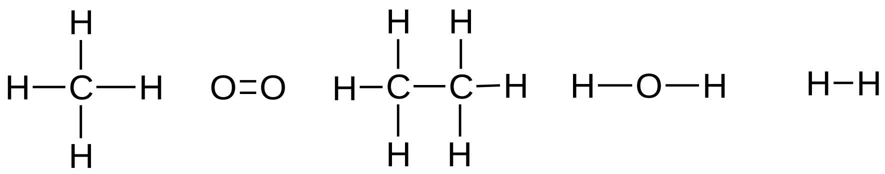
Assessor's use only

B3a (i) Calculate $\Delta_r H$ for the following reactions and use your results to decide which is the more favourable reaction. Give a reason for your answer.

$$2CH_{4(g)} \rightarrow C_2H_{6(g)} + H_{2(g)}$$

$$CH_{4(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow C_2H_{4(g)} + H_2O_{(g)}$$

Structural formulae are:



(ii) Calculate the enthalpy of the reaction, $\Delta_r H$, using the bond enthalpy data given below.

Bond	Bond dissociation enthalpy /kJ mol^{-1}
C-H	413
O=O	495
C-C	348
O-H	463
H-H	436

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

(iii) Use your results to (i) above to decide which is the more favourable reaction. Give a reason for your answer.

CheC: Aqueous Equilibrium Systems

Relate the properties of aqueous solutions to the nature and concentration of dissolved species.

Assessor's use only

Methanol gas, $CH_3OH_{(g)}$, can be prepared industrially from carbon monoxide, $CO_{(g)}$, and hydrogen, $H_{2(g)}$. This equilibrium can be represented by:

$$2H_{2(g)} + CO_{(g)} \rightleftharpoons CH_3OH_{(g)}$$

C1a Write the equilibrium constant expression for this reaction.

$K_c =$

Basic	Level
Excellent	
Weak	
NR	

C1b At 25°C the equilibrium constant is 2.20×10^{-4}. Calculate the concentration of $CO_{(g)}$ at equilibrium at 25°C, when the concentration of $H_{2(g)}$ is 3.05 mol L^{-1} and of $CH_3OH_{(g)}$ is 0.00120 mol L^{-1}.

Basic	Level
Excellent	
Weak	
NR	

At 300°C the equilibrium constant is 1.85×10^2.

C1c Explain how the increase in K_c with increasing temperature implies that the forward direction of the equilibrium reaction is endothermic.

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Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

Magnesium hydroxide, $Mg(OH)_2$ is a common component of antacid tablets used to control stomach acidity. It is a compound of low solubility in pure water:

$$K_s(Mg(OH)_2) \quad = \quad 7.1 \times 10^{-12}$$

The equilibrium equation for $Mg(OH)_2$ dissolving in water is:

$$Mg(OH)_{2(s)} \rightleftharpoons Mg^{2+}{}_{(aq)} + 2OH^{-}{}_{(aq)}$$

The expression for $K_s(Mg(OH)_2)$ is: $K_s = [Mg^{2+}][OH^-]^2$

C2a Calculate the solubility of $Mg(OH)_2$ in pure water in mol L^{-1}.

Basic	Level
Excellent	
Weak	
NR	

C2b Discuss how the solubility of $Mg(OH)_2$ will change as the pH decreases.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

CheD: Oxidation-Reduction

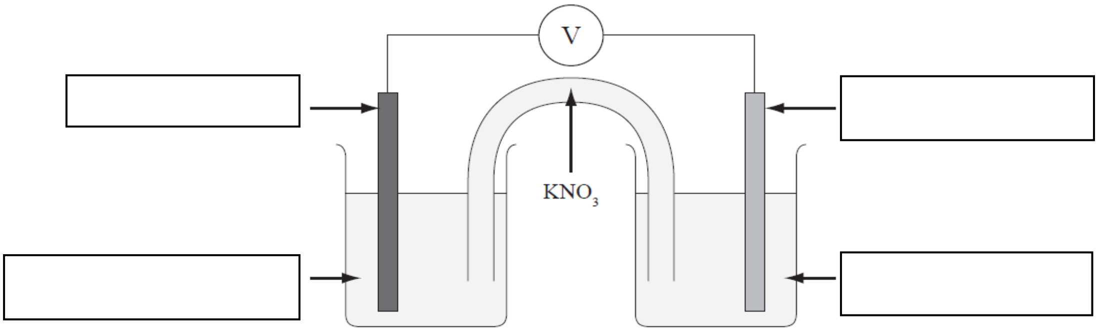
Apply oxidation-reduction principles to electrochemical cells and compare the relative strength of oxidants.

Assessor's use only

D1a The electrochemical cell drawn below is to be set up for the cell represented by the notation:

$Cu \mid Cu^{2+} \parallel Fe^{3+}, Fe^{2+} \mid C$

Complete the diagram below by labelling the electrodes and solutions so that the cell is set up according the notation given.



Basic	Level
Excellent	
Weak	
NR	

D1b Write an equation for the cell reaction.

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Basic	Level
Excellent	
Weak	
NR	

D1c Calculate the voltage on the voltmeter, when the cell is operating, using the electrode potentials given below.

$E°(Fe^{3+}/Fe^{2+}) = +0.77$ V $\qquad$ $E°(Cu^{2+}/Cu) = +0.34$ V

Basic	Level
Excellent	
Weak	
NR	

D2a Show, using the electrochemical data below, that the reaction between iron, Fe, and hydrogen peroxide, H_2O_2, is spontaneous.

$$Fe + H_2O_2 + 2H^+ \rightarrow Fe^{2+} + 2H_2O$$

$E°(Fe^{3+}/Fe^{2+}) = +0.77$ V $\qquad$ $E°(Fe^{2+}/Fe) = –0.44$ V

$E°(H_2O_2/H_2O) = +1.78$ V $\qquad$ $E°(O_2/H_2O_2) = +0.68$ V

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Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

Magnesium metal and chlorine gas can be extracted from crystals of magnesium chloride, $MgCl_2$, obtained from seawater. A mixture of magnesium chloride and other less active chlorides is heated to melt the salts and the resulting liquid is electrolysed. At the anode, a silver-gray metal is formed. At the cathode a gas is generated.

Basic	Level
Excellent	
Weak	
NR	

D3a Explain what is meant by the term "electrolysed".

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D3b Link the oxidation-reduction processes occurring at each electrode to the movement of electrons within the cell. Justify your answer by considering the spontaneity of the reaction and the calculated electrode potential for the cell reaction.

Redox couple	**E°/V**
Mg/Mg^{2+}	-2.36
Cl_2/Cl^-	+1.40

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Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

CheE: Organic Chemistry

Use information about the structure and reactions of organic molecules to solve problems in organic chemistry.

Assessor's use only

Complete the table below by giving the:

E1a systematic names for molecules 1 and 2.

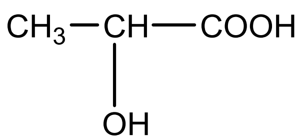
E1b structures for molecules 3 and 4.

	Structural formula	Systematic Name
1	$CH_3CH_2CH_2C(=O)Cl$	
2	$CH_3CH_2CH_2C(=O)-O-CH_2CH_3$	
3		3-methylhexan-2-one
4		2-amino-3-chloro-4-methylpentanoic acid

Basic	Level
Excellent	
Weak	
NR	

Basic	Level
Excellent	
Weak	
NR	

Lactic acid is the common name for 2-hydroxypropanoic acid:



E2a Lactic acid is optically active and is able to form enantiomers.

Mark the carbon responsible for the optical activity of lactic acid with *.

Explain what feature of this carbon allows lactic acid to form enantiomers.

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Basic	Level
Excellent	
Weak	
NR	

E2b Explain how the two enantiomers differ from each other.

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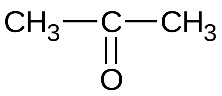
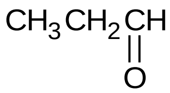
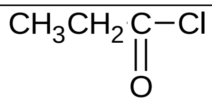
Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

E3a The labels on four bottles containing colourless liquids are unable to be read. The bottles, labelled A to D, are known to contain the following compounds.

			$CH_3CH_2CH_2NH_2$
propanone	propanal	propanoyl chloride	propanamine

The following tests are carried out and the observations recorded.

1. Each of the liquids was added dropwise to water in a test tube. The solution from bottle **A** reacted vigorously and gave off white vapour which turned blue litmus red.

2. The remaining solutions were tested with litmus and the solution from Bottle **C** turned red litmus blue.

3. The liquids from bottles **B** and **D** were reacted with Tollen's reagent. Only the liquid from bottle **D** formed a silver mirror.

Match the compounds **A** to **D** to the structures given in the boxes above. Give a brief reason for your answers relating the observations to the functional group reactions.

Compound A ______________________________

Reason: ____

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Compound B ______________________________

Reason: ____

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Compound C ______________________________

Reason: ____

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Compound D ______________________________

Reason: ____

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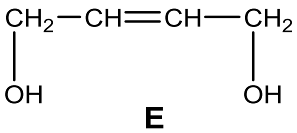
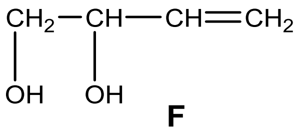
Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

Assessor's use only

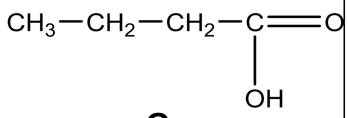
The structures of five constitutional isomers **E** to **I** are drawn below:



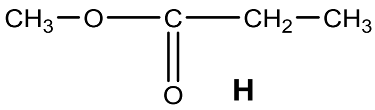
E



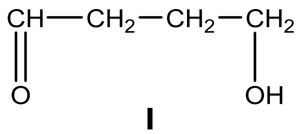
F



G



H



I

E4a Explain why these are all constitutional isomers.

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Basic	Level
Excellent	
Weak	
NR	

E4b Explain why all the isomers except **H** will react with $SOCl_2$.

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Give the name for this type of reaction: ________________________________

Basic	Level
Excellent	
Weak	
NR	

E4c Explain why only isomers **E, F** and **I** will react with acidified potassium dichromate solution.

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Basic	Level
Excellent	
Weak	
NR	

E4d Draw the structure of the product of the reaction of isomer **F** with acidified potassium dichromate.

Basic	Level
Excellent	
Weak	
NR	

E4e Draw the product of the reaction of isomer **I** with $LiAlH_4$.

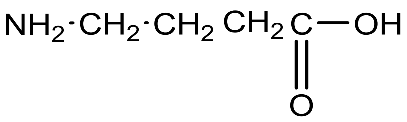
Basic	Level
Excellent	
Weak	
NR	

E4f Draw the structures of the two products of the reaction of isomer **H** with dilute sulfuric acid.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

E5a Draw 2 repeating units of the condensation polymer formed from the following monomer:



Basic	Level
Excellent	
Weak	
NR	

E5b Explain why this is called a condensation polymer. ______________________________

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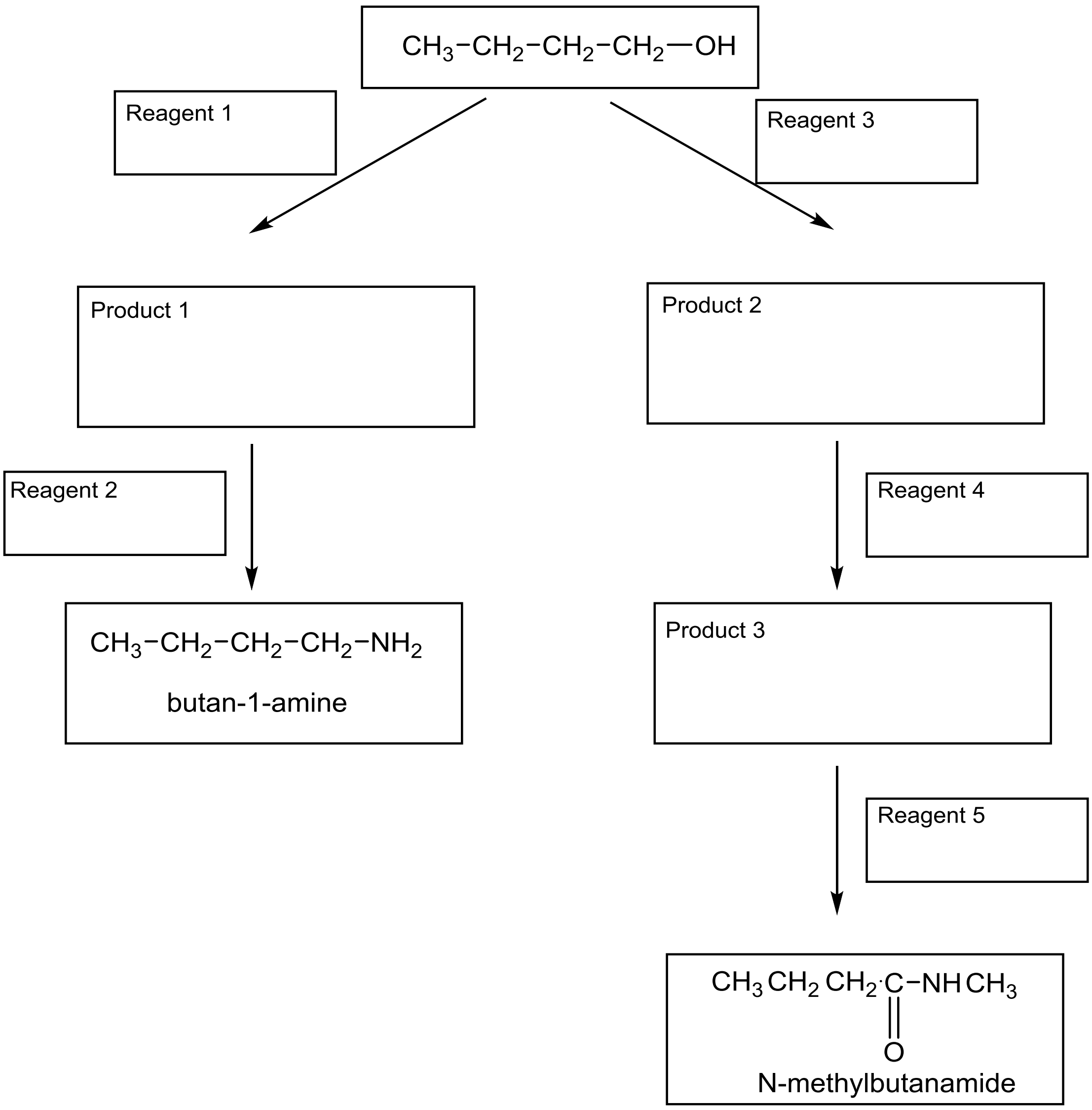
Basic	Level
Excellent	
Weak	
NR	

E6a Complete the following reaction scheme by giving the reagents 1 to 5 and the products 1 to 3.

E6b



Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

THE END