103/1

MARKER CODE

Student Personal Identification Number

South Pacific Form Seven Certificate

CHEMISTRY

2015

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	12 questions	3 questions	1 questions	21% 46 min
CheB: Use thermochemcial data to determine energy changes in chemical and physical processes	3 questions	1 questions	1 question	8% 20 min
CheC: Relate the properties of aqueous solutions to the nature and concentration of dissolved species	3 questions	1 questions	1 question	8% 20 min
CheD: Apply oxidation-reduction principles to electrochemical cells and compare the relative strength of oxidants	4 questions	1 questions	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 questions	19% 44 min
TOTAL	**34 questions**	**8 questions**	**5 questions**	**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

A1 Write the electron arrangement, using *s, p, d* notation, for the following:

As _____

Cu^{2+} _____

Basic	Level
Excellent	
Weak	
NR	

A2 (a) Explain why As^{3-} ions are bigger than As atoms.

_____

_____

_____

Basic	Level
Excellent	
Weak	
NR	

(b) Explain why As^{3-} ions are bigger that Se^{2-} ions

_____

_____

_____

Basic	Level
Excellent	
Weak	
NR	

A3 Explain why copper (II) compounds, containing Cu^{2+} ions are usually coloured but compounds that contain copper (I) ions, Cu^{+}, are not.

_____

_____

_____

Basic	Level
Excellent	
Weak	
NR	

A4 (a) Give the definition of Ionisation Enthalpy

_____

_____

Basic	Level
Excellent	
Weak	
NR	

(b) Explain why Ionisation Enthalpy is always positive

_____

_____

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

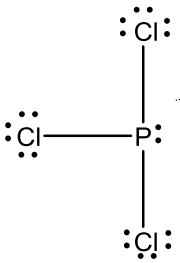
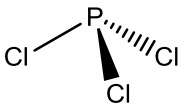
A4 (c) The Ionisation Enthalpy for arsenic is smaller than for phosphorus, which, in turn is smaller than for sulfur.

As < P < S

Give a reason for these differences, linking your answer to the electron configurations of the atoms.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

A5 In the table below the Lewis structure for the molecule PCl_3 is given. Complete the table by drawing the Lewis structure for the PCl_4^- ion and naming and drawing the shape of the ion.

	PCl_3	PCl_4^-
Lewis structure		(a)
Name of shape	Trigonal pyramid	(b)
Sketch of Shape		(c)

Basic	Level
Excellent	
Weak	
NR	

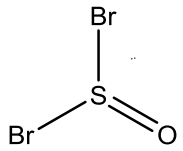
Basic	Level
Excellent	
Weak	
NR	

(d) Give a reason for the shape of the PCl_3 molecule

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

A6 Explain why the molecule $SOBr_2$, illustrated below, is polar.



Proficient	Level
Excellent	
Moderate	
Weak	
NR	

A7 Explain the differences in the melting points for each pair of substances given below. In each case identify and compare the intermolecular forces of each substance.

(a) Bromine, Br_2 has a melting point of -7^oC and chlorine, Cl_2 has a melting point of -101^oC.

Basic	Level
Excellent	
Weak	
NR	

(b) Bromofluoride, BrF, melts at a higher temperature than bromochloride, BrCl

Basic	Level
Excellent	
Weak	
NR	

(c) Water, H_2O melts at 0^oC but H_2S melts at -86^oC.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

A8

(a) Write a balanced equation for the nuclear reaction occurring when Cl-39 undergoes β emission

$^{39}Cl \rightarrow$ _____ + _____

Basic	Level
Excellent	
Weak	
NR	

(b) Calculate the half-life for the decay of Cl-39 if a 1.00 g sample decays to 0.125 g in 165 minutes.

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

B1 Phosphoric acid, $H_3PO_4(\ell)$ is a weak acid found in cola drinks.

Write the equation for which the energy change is the *enthalpy of formation,* $\Delta_f H$, of phosphoric acid. Note: phosphorus, in its standard state is P(s).

Basic	Level
Excellent	
Weak	
NR	

B2 Calculate the enthalpy for the reaction of $P_4O_{10}(s)$ with water to form phosphoric acid using the enthalpies of formation given below.

$$P_4O_{10}(s) + 6H_2O(\ell) \rightarrow 4H_3PO_4(aq)$$

$\Delta_f H(P_4O_{10}(s)) = -2984$ kJ mol^{-1}

$\Delta_f H(H_2O(\ell)) = -286$ kJ mol^{-1}

$\Delta_f H(H_3PO_4(aq)) = -1277$ kJ mol^{-1}

Basic	Level
Excellent	
Weak	
NR	

(a)

(b)

Basic	Level
Excellent	
Weak	
NR	

B3 Use the data provided to calculate the enthalpy change for the reaction of nitrogen and oxygen to form dinitrogen pentoxide,

$$2N_2(g) + 5O_2(g) \rightarrow 2N_2O_5(g)$$

$N_2(g) + 3O_2(g) + H_2(g) \rightarrow 2HNO_3(aq)$ $\quad \Delta_r H^\circ = -415$ kJ mol^{-1}

$N_2O_5(g) + H_2O(\ell) \rightarrow 2HNO_3(aq)$ $\quad \Delta_r H^\circ = -140$ kJ mol^{-1}

$2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$ $\quad \Delta_r H^\circ = -572$ kJ mol^{-1}

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

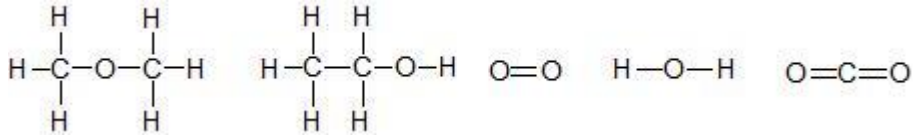
Assessor's use only

B4 Both dimethyl ether, CH_3-O-CH_3, and ethanol, CH_3CH_2OH, have been suggested as possible fuels. The combustion reactions with oxygen both release carbon dioxide and water:

$$CH_3OCH_3(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

$$CH_3CH_2OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

Structural formulae are:



Calculate the enthalpy of combustion, $\Delta_c H$, for both CH_3-O-CH_3, and CH_3CH_2OH and determine which is the more efficient fuel.

Bond	Bond dissociation enthalpy /kJ mol^{-1}
C-H	414
O=O	498
C-C	346
O-H	463
C-O	358
C=O	804

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

CheC: Aqueous Equilibrium Systems

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

Assessor's use only

C1 Gaseous molecular iodine, $I_2(g)$ and hydrogen gas, $H_2(g)$ can be reacted to form HI(g)

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$$

(a) Write the equilibrium constant expression for this reaction.

K_c =

Basic	Level
Excellent	
Weak	
NR	

(b) At 350°C the equilibrium constant K_c for this reaction is 60.

In a mixture the concentration of H_2 and HI gases are 0.10 mol L^{-1} and the concentration of $I_2(g)$ is 0.001 mol L^{-1}

Determine whether the reaction is at equilibrium. Show your working.

Basic	Level
Excellent	
Weak	
NR	

(c) At 1000°C the equilibrium constant K_c is 30. Explain how this drop in the value of K_c is consistent with this reaction being exothermic.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

(d) Explain how an equilibrium mixture of gaseous H_2 and I_2 would respond to an increase in pressure. Give a reason for your answer.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

C2 Calcium fluoride, $CaF_2(s)$, is sparingly soluble salt.

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq) \quad K_s = 3.2 \times 10^{-11}$$

- Write the expression for the solubility product
- Calculate the solubility of calcium fluoride, CaF_2, in water in mol L^{-1}
- Explain why the solubility of CaF_2 decreases when calcium fluoride is added to a solution containing the more soluble calcium chloride, $CaCl_2(aq)$.

Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

Expression:

K_s =

Calculation:

Explanation:

CheD: Oxidation-Reduction

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

Assessor's use only

D1 An electrochemical cell is formed by linking two half-cells with a salt bridge. A cell is set up so that the cell reaction is:

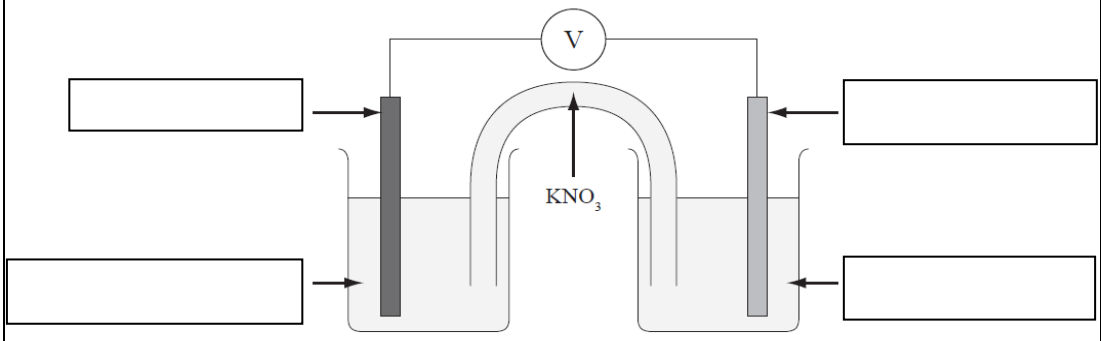
$$Cu^{2+} + Sn^{2+} \rightarrow Cu + Sn^{4+}$$

(a) The following chemicals are available to construct the cell:

Copper (Cu) and platinum (Pt) electrodes

0.1 mol L^{-1} solutions of the ions Cu^{2+}, Sn^{2+} and Sn^{4+}

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



Basic	Level
Excellent	
Weak	
NR	

(b) Write the cell notation for the cell drawn above in the box below.

|	||	|

Basic	Level
Excellent	
Weak	
NR	

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

$E°(Sn^{4+}/Sn^{2+}) = +0.15$ V $E°(Cu^{2+}/Cu) = +0.34$ V

Basic	Level
Excellent	
Weak	
NR	

(d) Use your answer to (c) above to decide whether or not a piece of copper metal will react when placed in a solution of tin (IV) chloride. Justify your answer.

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Assessor's use only

D2 Nickel-cadmium batteries are rechargeable. When the cell is operating electricity is generated until the cell components are used up. The cell can then be recharged in a process known as electrolysis.

The cell reaction that generates electricity is:

$$2NiO(OH) + Cd + 2H_2O \rightarrow 2Ni(OH)_2 + Cd(OH)_2$$

(a) Identify the element that is being oxidised in this reaction. Give a reason for your answer.

Basic	Level
Excellent	
Weak	
NR	

(b) The standard electrode potentials for the redox couples in basic conditions are:

$E^\circ(Cd(OH)_2/Cd) = -0.88$ V $\quad$ $E^\circ(NiO(OH)/Ni(OH)_2) = +0.52$ V

Calculate the E^o for the cell and explain how the process of electrolysis is able to recharge the battery.

Calculation:

Explanation:

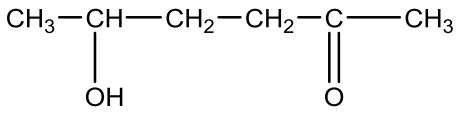
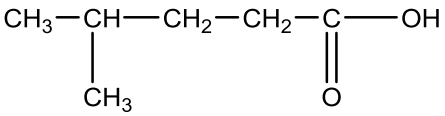
Advanced	Level
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	

CheE: Organic Chemistry

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

Assessor's use only

E1 Two molecules A and B are drawn below:

Molecule A	Molecule B
	

(a) Give the systematic names for these molecules.

Molecule A _____

Molecule B _____

Basic	Level
Excellent	
Weak	
NR	

(b) Determine whether Molecules A and B are constitutional (structural) isomers and give a reason for your answer.

_____

_____

Basic	Level
Excellent	
Weak	
NR	

(c) Only Molecule A can exist as enantiomers.

(i) Draw a * on the structure to indicate the chiral carbon

Basic	Level
Excellent	
Weak	
NR	

(ii) Describe the relationship between the two enantiomers

_____

_____

Basic	Level
Excellent	
Weak	
NR	

(d) One way to distinguish between Compound A and Compound B would be to add acidified potassium permanganate, $KMnO_4/H^+$.

Circle the letter for the molecule which reacts with $KMnO_4/H^+$.

A or B

Write what would be observed as the reaction proceeds.

_____

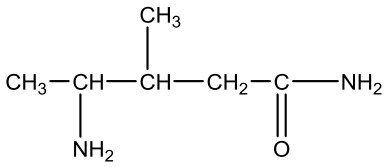
_____

Proficient	Level
Excellent	
Moderate	
Weak	
NR	

Draw the structure of the reaction product.

Assessor's use only

E2 Molecule C is drawn below:



Proficient	Level
Excellent	
Moderate	
Weak	
NR	

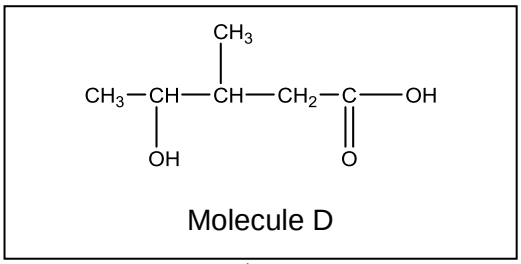
(a) Circle and label the functional groups in Molecule C.

(b) Draw a # beside the functional group which gives this molecule its basic properties

Basic	Level
Excellent	
Weak	
NR	

(c) Molecule C can be prepared in a two-step reaction scheme starting with Molecule D.

Complete the reaction scheme below by giving reagent A and Structure W for this reaction scheme.

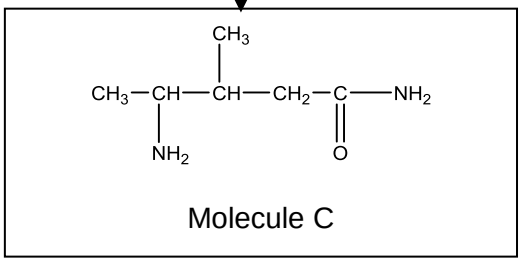


i. Reagent 1

Basic	Level
Excellent	
Weak	
NR	

. Structure W

ii NH_3 (conc)

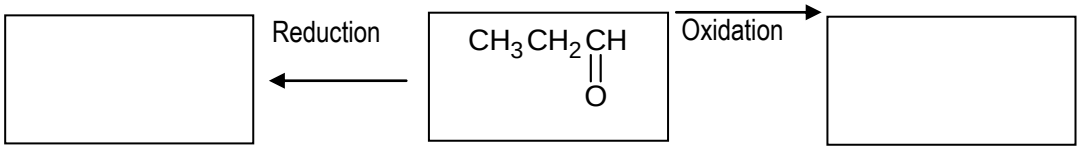


Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

E3 (a) Aldehydes are compounds which are able to be both oxidised and reduced depending on the reaction conditions.

(i) Draw the structure of the reaction product for each of the oxidation and reduction reactions for the aldehyde given below,



Basic	Level
Excellent	
Weak	
NR	

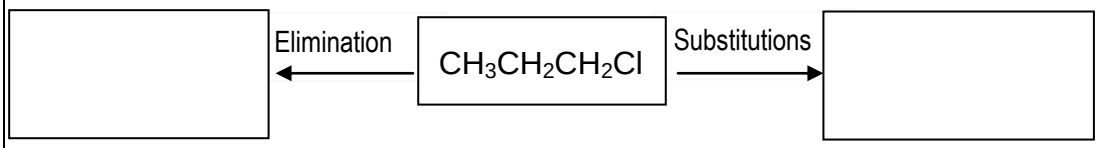
(ii) Identify the reagents for: reduction: _____

oxidation: _____

Basic	Level
Excellent	
Weak	
NR	

(b) Depending on the reaction conditions, a haloalkane can undergo either substitution of elimination with KOH.

Identify the conditions and draw the structure of the reaction product for each of the substitution and elimination reactions for the haloalkane given below,

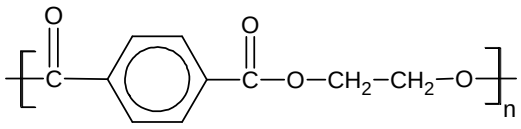


Basic	Level
Excellent	
Weak	
NR	

Conditions for elimination: _____

Conditions for substitution: _____

(c) Mylar® is a polymeric material that is often used to make shiny helium balloons. The polymer has the following structure:



(i) Circle and name the functional group in this polymer.

Functional group: _____

Basic	Level
Excellent	
Weak	
NR	

(ii) Draw the structures of the two molecules that could combine to make this polymer.

Basic	Level
Excellent	
Weak	
NR	

Assessor's use only

E4 Four organic compounds cyclohexene, pentanal, 2-chlorobutanoic acid and propanoyl chloride are all colourless liquids.

Draw the structures of each of these compounds

Name	**Structure**
cyclohexene	
pentanal	
2-chlorobutanoic acid	
propanoyl chloride	

Reagents to identify each of these compounds can be found in the list below.

Water, Tollens' reagent ($AgNO_3$ with ammonia), bromine water ($Br_2(aq)$), litmus paper, thionyl chloride ($SOCl_2$)

Describe the chemical reactions that could be carried out to and the expected observations that would identify each of these 4 compounds.

Advanced	**Level**
Excellent	
Moderate	
Low	
Weak	
NR	
Exceed	