Theory

Year 11 Preliminary Chemistry Exam 2016

General Instructions

- **Reading Time**: 5 minutes
- **Working Time**: 50 minutes
- Write using black pen
- Board approved calculators may be used
- Write your Student Number at the top of page 7
- A Periodic Table and Data sheet are provided

Total Marks : 46

Part A

Multiple Choice: 12 marks

Attempt Questions 1-12

Allow about 12 minutes for this part.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

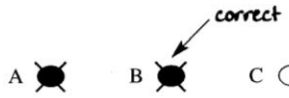
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



- **Mark your answers for Questions 1 – 12 in the Answer Box on page 7**

1. Which of the following is NOT a good indicator of a chemical reaction?

   (A) a pungent gas is produced

   (B) a colour change occurs

   (C) a precipitate is produced

   (D) a change of state occurs

2. Which characteristic of water allows the coin to float?

   (A) surface tension

   (B) capillarity

   (C) viscosity

   (D) density

3. Which experimental observation correctly details Gay-Lussac's contribution to the mole concept?

   (A) The ratio of the volumes of gases involved in a reaction, if measured at the same temperature and pressure, are present in non-whole number ratios.

   (B) The ratios of the volumes of gases involved in a reaction, if measured at the same temperature and pressure, are present as whole number ratios.

   (C) Equal volumes of all gases, measured at the same temperature and pressure, contain equal numbers of molecules.

   (D) Equal volumes of all gases, measured at the same temperature and pressure, contain the equal number of moles.

4. The specific heat capacities for a range of commonly used laboratory solvents is given in the table below.

Solvent	*Specific heat capacity* $(J\ g^{-1}\ K^{-1})$
Water	4.18
Hexane	2.26
Ethyl acetate	1.94
Toluene	1.13

Which solvent would display the largest change in temperature when exposed to the same amount of heat?

(A) Water

(B) Hexane

(C) Ethyl acetate

(D) Toluene

5. How many hydrogen atoms are present in 2 moles of $(NH_4)_2CO_3$?

(A) 2.4×10^{24}

(B) 4.8×10^{24}

(C) 6.0×10^{24}

(D) 9.6×10^{24}

6. Stockpiles of coal are kept wet to prevent explosions that may occur due to the presence of coal dust.

Which statement best identifies the necessity for this precaution?

(A) The surface area of the coal dust is larger than coal.

(B) The energy profiles for the combustion of coal dust and coal are different.

(C) The activation energy for coal dust is lower than the activation energy for coal.

(D) Coal dust reaches its ignition temperature before coal.

7. Which option correctly identifies the percentage of water in the different spheres?

	Sphere	*% water*
(A)	lithosphere	25 %
(B)	biosphere	70%
(C)	hydrosphere	90%
(D)	atmosphere	0.03%

8. Which statement best defines ignition temperature?

(A) The lowest temperature at which the fuel rapidly becomes a vapour.

(B) The lowest temperature to which a fuel must be heated, in the presence of oxygen, to ignite it with a spark or a flame.

(C) The lowest temperature to which a fuel must be heated, in the presence of oxygen, to ignite it without a spark or a flame.

(D) The lowest temperature at which the fuel mixes spontaneously with air.

9. At what temperature is water most dense?

(A) - 4 ^{o}C

(B) 0 ^{o}C

(C) 4 ^{o}C

(D) 100 ^{o}C

10. Which equation represents the complete combustion of ethanol?

(A) $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

(B) $2C_2H_5OH(l) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

(C) $C_2H_5OH(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

(D) $C_2H_5OH(l) + 3O_2(g) \rightarrow CO(g) + CO_2(g) + 3H_2O(l)$

11. Which of the following contains the largest number of nitrate ions?

(A) 250 mL of 0.30 mol L^{-1} aluminium nitrate, $Al(NO_3)_3$.

(B) 300 mL of 0.20 mol L^{-1} thorium nitrate, $Th(NO_3)_4$.

(C) 400 mL of 0.45 mol L^{-1} sodium nitrate, $NaNO_3$.

(D) 500 mL of 0.30 mol L^{-1} calcium nitrate $Ca(NO_3)_2$.

12. What mass of glucose ($C_6H_{12}O_6$) is required to prepare 200 mL of a 0.25 mol L^{-1} solution?

(A) 0.0500 g

(B) 9.01 g

(C) 50.0 g

(D) 90.1 g

Student Number .....

Part A . Answer grid for multiple choice questions

Total ...../46

1.	A O	B O	C O	D O
2.	A O	B O	C O	D O
3.	A O	B O	C O	D O
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Total ...../12

Part B. 34 marks
Attempt questions 13 - 19
Allow about 40 minutes for this part
▸ *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response*
▸ *Show all relevant working in questions involving calculations*

Question 13 (5 marks)

An unknown compound measuring 14.99 g contains 6.00 g carbon, 0.99 g hydrogen and the remainder is oxygen.

(a) Determine the empirical formula of the unknown compound. **3**

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(b) Outline the difference between molecular and empirical formula. **2**

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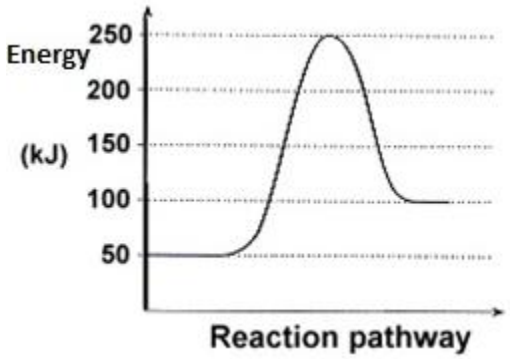
Question 14 (5 marks)

The graph below represents an energy profile diagram for a reaction.



(a) Determine ΔH for the reaction. **1**

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(b) Determine the activation energy for the reaction. **1**

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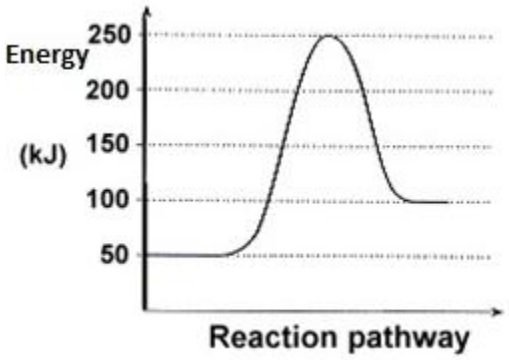
(c) Draw on the graph the reaction pathway if a catalyst is added to the reaction using a dotted line. **1**



(d) Explain the effect of a catalyst on the rate of the reaction. **2**

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Question 15 (3 marks)

The molar heat of solution for ammonium chloride is +14.8 kJ mol^{-1}.

Calculate the change in temperature of the solution when 40.1 g of ammonium chloride is dissolved in 100 mL of water. **3**

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Question 16 (5 marks)

Fossil fuels are commonly described as "stored solar energy".

Justify this statement. Include a relevant equation. **5**

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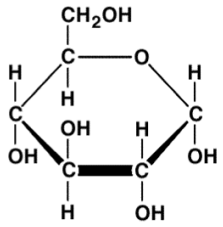
Potassium chloride and glucose ($C_6H_{12}O_6$) are both white solids that easily dissolve in water. The structure of glucose is drawn below.



Compare the nature of the dissolution of each of these solids in water in terms of their structure and bonding. **6**

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(c) Calculate the concentration of chloride ions in the final solution. **2**

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Hydrogen sulfide gas and water have similar structures but different boiling points.

(a) Draw a Lewis electron dot structure for hydrogen sulfide showing the shape of the molecule. **2**

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End of Theory Exam

Theory

With Answers

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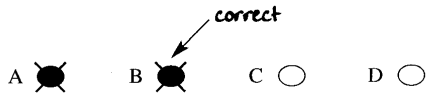

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(C) C_2H_5OH*(l)* + O_2*(g)* → CO_2*(g)* + H_2O*(l)*

(D) C_2H_5OH*(l)* + $3O_2$*(g)* → CO*(g)* + CO_2*(g)* + $3H_2O$*(l)*

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Total ...../12

Part B. 34 marks
Attempt questions 13- 19
Allow about 40 minutes for this part
▸ *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response*
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Question 13 (5 marks)

An unknown compound measuring 14.99 g contains 6.00 g carbon, 0.99 g hydrogen and the remainder is oxygen.

(a) Determine the empirical formula of the unknown compound. **3**

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Sample Answer :

n(carbon) = 6.00 / 12.01 = 0.50 mol
n(hydrogen) = 0.99 / 1.008 = 0.98 mol
m(oxygen) = 14.99 – (6.00 + 0.99) = 8.00 g *1 mark*
m(oxygen) = 8.00 / 16.00 = 0.50 mol
ratio = 0.50 (C): 0.98 (H): 0.50 (O)
ratio = 1:2:1 *1 mark*
empirical formula = CH_2O *1 mark*

Outcomes: P10

Criteria	Marks
• Correctly determines the empirical formula CH_2O • Includes correct working out (ratio of elements and oxygen calculation).	3
• Includes appropriate working out (ratio of elements and / or oxygen calculation)	2
• Includes attempted working out	1

(b) Outline the difference between molecular and empirical formula. **2**

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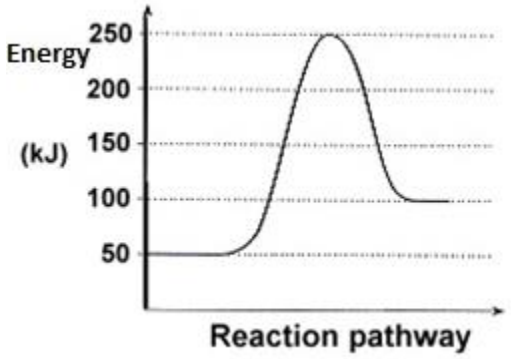
Sample Answer:

The molecular formula includes the number of atoms of each element present within one molecule of a compound whereas the empirical formula merely details the simplest ratio of atoms of elements within a compound.

Criteria	Marks
• Correctly identifies molecular and empirical formula	2
• Attempts to identify molecular and / or empirical formula	1

Question 14(5 marks)

The graph below represents an energy profile diagram for a reaction.



(a) Determine ΔH for the reaction. **1**

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Sample Answer :ΔH = + 50 kJ

(b) Determine the activation energy for the reaction. **1**

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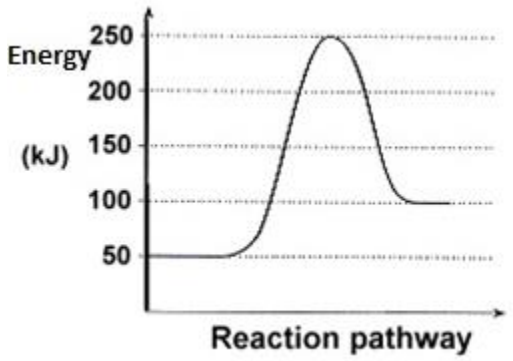
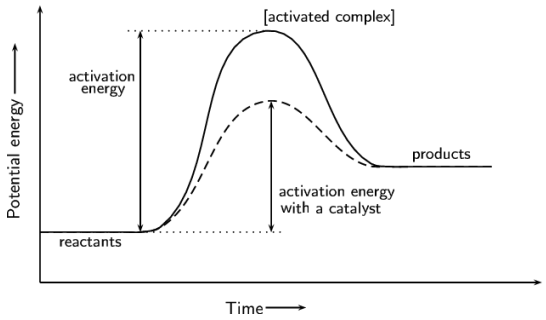
Sample Answer : E_A = 200 kJ

(c) Draw on the graph the reaction pathway if a catalyst is added to the reaction using a dotted line. **1**





(d) Explain the effect of a catalyst on the rate of the reaction. **2**

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Sample Answer:

A catalyst will speed up a reaction by lowering the activation energy required for successful collisions. A catalyst does this by providing an alternate pathway for the reaction with lower activation energy.

Marking Criteria	*Marks*
• *Explains the effect of a catalyst on reaction rate*	*2*
• *Outlines the effect of a catalyst on reaction rate*	*1*

Question 15 (3 marks)

The molar heat of solution for ammonium chloride is +14.8 kJ mol^{-1}.

Calculate the change in temperature of the solution when 40.1 g of ammonium chloride is dissolved in 100 mL of water. **3**

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Sample Answer :

$\Delta H = - mc\Delta T,$
$AH = +14.8\ kJ\ mol^{-1}$
$n(NH4Cl) = 40.1\ g / (14.01 + 1.008 \times 4 + 35.45) = 0.75$ *1 mark*
$\Delta T = \Delta H \times$ mole ratio $/ - mc$
$\Delta T = +14800 \times 0.75 / - 100 \times 4.18$ *1 mark*
$\Delta T = - 26.5\ ^oC$ *1 mark*

Criteria	Marks
• Correctly calculates the negative temperature change. • Includes correct working out (mole calculation and substitution into reverted equation with correct units).	3
• Correctly calculates the temperature change. • Includes appropriate working out (mole calculation and substitution into reverted equation with correct units).	2
• Includes attempted working out	1

Question 16 (5 marks)

Fossil fuels are commonly described as "stored solar energy".

Justify this statement. Include a relevant equation. **5**

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Sample Answer :

Sunlight is the most abundant source of energy and many biological organisms take advantage of this fact. Fossil fuels are considered stored solar energy because they hydrocarbon molecules that are derived from the remains of ancient plant and animal matter that has decomposed over thousands of years. Plants convert sunlight into chemical energy via photosynthesis, which takes singular carbon units from the environment, in the form of carbon dioxide and water to produce carbohydrates in the reaction shown below:

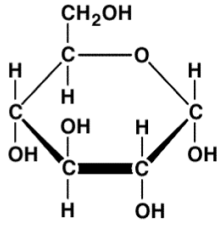
carbon dioxide + water → carbohydrate / glucose + oxygen

The solar energy that is converted into chemical energy in the form of carbohydrates and sugars is stockpiled in plants and used to sustain their growth. This stored energy is also transferred up the food chain into animals that eat these plants and so on up the food chain. In turn both these plants and animals will end up deceased and decompose into the hydrocarbon compounds we term fossil fuels, which has the origins of its energy derived from the sun.

Criteria	Marks
• Provides a detailed justification for the statement "stored solar energy" using the origins of energy from the sun. • Provides a detailed description of the production of fossil fuels (conversion of carbon dioxide to carbohydrates / glucose in plants via photosynthesis / sunlight, conversion of stored energy such as starch / glucose into hydrocarbons, and the decomposition of dead plant / animal matter). • Provides a correct equation for photosynthesis.	5
• Provides a justification for the statement "stored solar energy" using the origins of energy from the sun. • Provides a description of the production of fossil fuels (conversion of carbon dioxide to carbohydrates / glucose in plants via photosynthesis / sunlight, conversion of stored energy such as starch / glucose into hydrocarbons, and the decomposition of dead plant / animal matter). • Provides a relevant word equation for photosynthesis.	4
• Identifies the link between fossil fuels and the products of photosynthesis. • Outlines the production of fossil fuels (conversion of carbon dioxide to carbohydrates / glucose in plants via photosynthesis / sunlight, conversion of stored energy such as starch / glucose into hydrocarbons, and the decomposition of dead plant / animal matter). • Provides a relevant word equation for photosynthesis.	3
• Identifies the link between fossil fuels and the products of photosynthesis. • Includes relevant chemistry behind the production of fossil fuels and / or chemical equations.	2
• Provides some relevant information.	1

Question 17 (6 marks)

Potassium chloride and glucose ($C_6H_{12}O_6$) are both white solids that easily dissolve in water. The structure of glucose is drawn below.



Compare the nature of the dissolution of each of these solids in water in terms of their structure and bonding. **6**

Sample answer
Potassium chloride is made up of alternating cations and anions in a 3 dimensional crystal lattice. When dissolving, the ionic bonds break and the polar ends of the water molecules surround the ions. The positive H ends surround the negative chloride ions and the negative oxygen ends of the water molecules surround the positive potassium ions. Potassium chloride dissociates into its ions in water.
Glucose is made up of discreet covalent molecules. The molecules are held together in the solid by dispersion forces and H-bonding as there are polar hydroxyl groups in the molecule. When dissolving in water the dispersion forces and H-bonds between the molecules are overcome and the glucose molecules H –bond with polar water molecules. The molecules remain intact.

Marking Criteria	*Marks*
• *Thoroughly describes the nature of the dissolution of glucose and KCl in terms of the structure of the solids and the intermolecular forces overcome/formed*	*6*
• *Describes the nature of the dissolution of glucose and KCl in terms of the structure of the solids and the intermolecular forces overcome.*	*5*
• *Describes the nature of the dissolution of glucose and KCl in terms of the intermolecular forces overcome. OR* • *Describes the nature of the dissolution of glucose OR KCl in terms of the the intermolecular forces overcome and describing the change in the structure of one of the solids OR* • *Outlines the nature of the dissolution of glucose and KCl and identifies the structures as covalent molecular and ionic lattice*	*4*
• *Outlines the nature of the dissolution of glucose and KCl. OR* • *Describes the nature of the dissolution of glucose OR KCl*	*3*
• *Shows a basic understanding of one of the dissolutions or the structure of one of the solids.*	*2*
• *Gives some relevant information*	*1*

Question 18 (6 marks)

20.0 mL of 0.500 mol L^{-1} solution of barium chloride is added to 20.0 mL of 0.400 mol L^{-1} solution of sodium carbonate and a white precipitate forms.

(a) Write a balanced equation for the chemical reaction. **1**

Sample Answer:

$BaCl_2$ (aq) + Na_2CO_3 (aq) → $BaCO_3$ (s) + 2NaCl (aq)

(b) Calculate the mass of precipitate formed. **3**

Sample Answer:

$BaCl_2$ (aq) + Na_2CO_3 (aq) → $BaCO_3$ (s) + 2NaCl (aq)
mol $BaCl_2$ = M x V = 0.500 x 0.0200 = 0.0100
mol Na_2CO_3= M x V = 0.400 x 0.0200 = 0.00800
$BaCl_2$ is in excess and Na_2CO_3 is the limiting reagent.
mol $BaCO_3$ precipitated = 0.00800
mass $BaCO_3$ = mol x molar mass = 0.00800 x (137.3+12.01+ 3(16.00))= 1.58 g

Marking Criteria	*Marks*
• *Shows all relevant working and correctly calculates the mass of precipitate*	*3*
• *Shows some relevant working*	*2*
• *Gives an equation for the reaction OR* • *Shows a limited understanding of the relevant working*	*1*

(c) Calculate the concentration of chloride ions in the final solution. **2**

Sample Answer :

mol Cl^- = 2 x mol $BaCl_2$ = 2 x 0.0100 = 0.0200 mol
[Cl^-] = mol/V = 0.0200/ 0.0400 = 0.500 mol L^{-1}

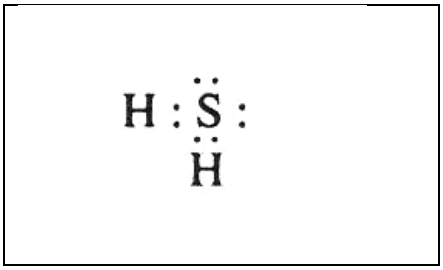
Marking Criteria	*Marks*
• *Uses molar relationship to find mol chloride ions* • *Divides by the total volume to find concentration*	*2*
• *Gives some relevant calculation*	*1*

Question 19 (5 marks)

Hydrogen sulfide gas and water have similar structures but different boiling points.

(a) Draw a Lewis electron dot structure for hydrogen sulfide showing the shape of the molecule. **2**

Sample Answer :



Correctly draws the Lewis dot structure (1 mark) and shows the bent shape.(1 mark)

(b) Explain the difference in the boiling points of hydrogen sulfide and water. **3**

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Sample answer
Hydrogen sulfide is a gas and has a lower boiling point than water. There are dipole-dipole and weak dispersion forces between the molecules of H_2S which are easily overcome by a small amount of energy so the boiling point is low. There are dispersion forces and H-bonds between the molecules of water as water is polar. These extra intermolecular forces require more energy to be overcome so the boiling point of water is higher.

Marking Criteria	*Marks*
• *Identifies the intermolecular forces between each of the substances and explains why water has a higher boiling point than hydrogen sulfide*	*3*
• *Identifies that water has a higher boiling point than hydrogen sulfide* • *Identifies some intermolecular forces*	*2*
• *Identifies that water has a higher boiling point than hydrogen sulfide OR* • *Identifies one type of intermolecular force*	*1*

End of Theory Exam