2020

JAMES RUSE AGRICULTURAL HIGH SCHOOL

YEAR 11 THEORY EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formula sheet, data sheet and Periodic Table are provided.

Total Marks – 60

Section I – 20 marks (pages 2 – 10)

- Attempt questions 1 – 20
- Allow about 30 minutes for this section

Section II – 40 marks (pages 11 – 22)

- Attempt questions 21 – 29
- Allow about 1 hours for this section

Section I

20 marks
Attempt Questions 1-20
Allow about 30 minutes for this section
Mark your answers on the ANSWER grid in the Answer booklet on page 11.

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.

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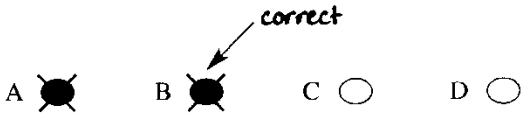
If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



1 Which of the following would involve an increase in entropy?

A. $2\ HCl(g) \rightarrow H_2(g) + Cl_2(g)$

B. $Na_2CO_3(s) \rightarrow Na_2CO_3(aq)$

C. $3\ H_2(g) + N_2(g) \rightarrow 2\ NH_3(g)$

D. $Fe(l) \rightarrow Fe(s)$

2 $P_1V_1 = P_2V_2$ represents whose Law?

A. Boyle's Law

B. Charles' law

C. Avogadro's Law

D. Gay-Lussac's Law

3 How many molecules are present in 247.9 L of methane at 298 K and 100 kPa?

A. 3.0×10^{23}

B. 6.0×10^{23}

C. 3.0×10^{24}

D. 6.0×10^{24}

4 Solid sulfur is extracted from the earth by melting sulfur deposits using superheated steam under pressure, then solidifying the sulfur into a different crystalline form to the original deposit.

What type of changes occurs in this process of extracting sulfur?

A. physical changes only.

B. chemical changes only.

C. both physical and chemical changes.

D. neither physical nor chemical changes.

5 There could be a risk of explosion in a flour mill due to the presence of fine flour particles, hence strict safety precautions are adhered to in these mills.

Which of the following statements is the best explanation for this?

A. The activation energy for the reaction of fine particles is much lower than for large particles.

B. The surface area of the flour particles is very large and thus combustion reactions are very fast.

C. It is very easy to heat the fine particles of flour to the ignition temperature.

D. When flour is ground to fine particles the energy profile diagram for the combustion reaction is changed.

6 Which is the correct balanced formula equation for the reaction of calcium with water?

A. $Ca(s) + H_2O(l) \rightarrow CaOH(aq) + H_2(g)$

B. $Ca(s) + 2\ H_2O(aq) \rightarrow Ca(OH)_2(l) + H_2(l)$

C. $Ca(s) + 2\ H_2O(aq) \rightarrow Ca(OH)_3(l) + H_2(g)$

D. $Ca(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

7 Boron is made up of two isotopes with mass numbers of 10 and 11.

Determine the percentages of the two isotopes of Boron given the relative atomic mass is 10.81.

	Boron-10	*Boron-11*
A.	18.3 %	81.7 %
B.	81.5 %	18.5 %
C.	18.8 %	81.2 %
D.	81.1 %	18.9 %

8 Respiration occurs via the following chemical reaction:

$$C_6H_{12}O_6(s) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$$

Which of the following has NO effect on the value of the enthalpy of reaction?

A. $\Delta H_{formation}\ (O_2)$

B. $\Delta H_{formation}\ (CO_2)$

C. $\Delta H_{formation}\ (H_2O)$

D. $\Delta H_{formation}\ (C_6H_{12}O_6)$

9 The formula for potassium perchlorate is $KClO_4$.

What is the formula for chromium (II) perchlorate?

A. $CrClO_4$

B. Cr_2ClO_4

C. $CrKClO_4$

D. $Cr(ClO_4)_2$

10 Which of the following correctly identifies the gas or gases produced when hydrochloric acid is reacted with zinc, sodium hydroxide, sodium carbonate and sodium hydrogen carbonate, respectively.

	Zinc	*Sodium hydroxide*	*Sodium carbonate*	*Sodium hydrogen carbonate*
A.	no gas produced	hydrogen	carbon dioxide	carbon dioxide
B.	hydrogen	no gas produced	carbon dioxide	carbon dioxide and hydrogen
C.	carbon dioxide	carbon dioxide	hydrogen	no gas produced
D.	hydrogen	no gas produced	carbon dioxide	carbon dioxide

11 A solution is prepared by dissolving 1.50 g of barium hydroxide in enough water to produce 1.00 L of solution. What is the concentration of hydroxide ions in the final solution?

A. 3.00 g L^{-1}

B. 0.0088 mol L^{-1}

C. 0.0175 mol L^{-1}

D. 1.50 g L^{-1}

12 Element X forms the following ionic compound:

$$XCl_3$$

What is the correct spdf notation for X in this compound?

A. $1s^2\ 2s^2\ 2p^6$

B. $1s^2\ 2s^2\ 2p^6\ 3s^2$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

13 $^{13}_{7}N$ is a beta emitter.

What isotope does it decay into?

A. $^{13}_{6}C$

B. $^{13}_{8}O$

C. $^{14}_{7}N$

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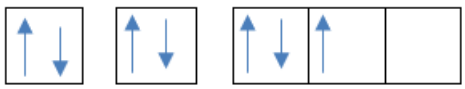
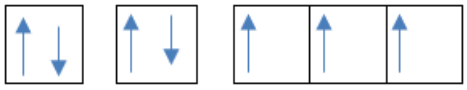
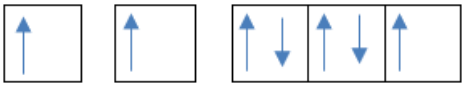
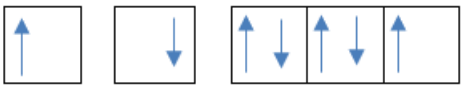
14 Which orbital diagram represents nitrogen?

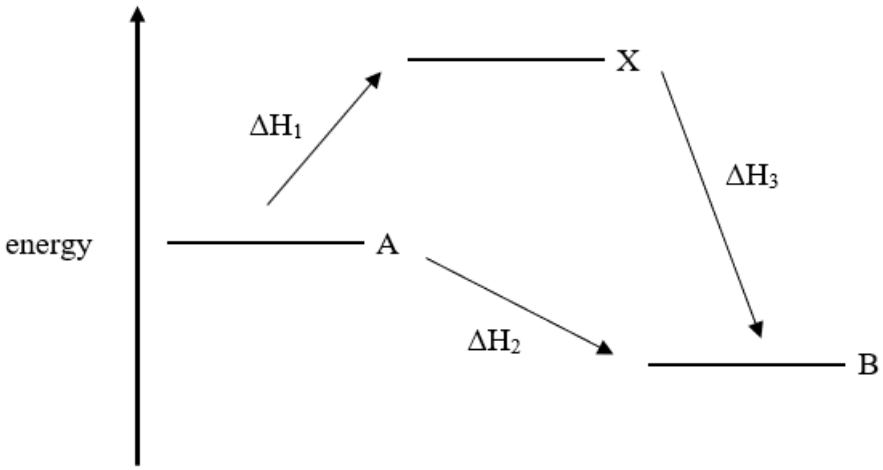
A. 

B. 

C. 

D. 

15 The energy cycle diagram shown below represents the conversion of reactants, A into products, B. This chemical reaction can occur directly from reactants to products or via intermediate, X.



Which of the following statements correctly demonstrates Hess' law?

A. $\Delta H_1 = \Delta H_2 + \Delta H_3$

B. $\Delta H_3 = \Delta H_1 + \Delta H_2$

C. $\Delta H_2 = \Delta H_1 + \Delta H_3$

D. $\Delta H_1 = \Delta H_3 - \Delta H_2$

16 The following equation represents the reaction occurring inside a car battery.

$$a\ Pb(s) + b\ PbO_2(s) + c\ H_2SO_4(aq) \rightarrow d\ PbSO_4(s) + e\ H_2O(l)$$

The stoichiometric values for a, b, c, d and e in the equation are:

A. 1, 1, 1, 2, 2

B. 1, 1, 2, 2, 2

C. 2, 2, 2, 2, 1

D. 1, 1, 1, 1, 2

17 The following reduction couples and their E^0 values have been taken from a table of standard reduction potentials.

Reduction couples	*E^o (V)*
Co^{2+} / Co	–0.28
Cu^{2+} / Cu	0.34
Mn^{2+} / Mn	–1.18
Ru^{2+} / Ru	0.46

Which would be the correct order of reactivity if the metals are ranked in order of decreasing electrochemical reactivity?

A. Co > Mn > Cu > Ru

B. Ru > Cu > Co > Mn

C. Mn > Ru > Cu > Co

D. Mn > Co > Cu > Ru

18 A weather balloon contains 55 L of helium gas. This is released at sea level where the conditions are 105 kPa and 23 ^{o}C.

What is the change in volume of the weather balloon when it reaches its maximum altitude where the conditions are 7 kPa and –5 ^{o}C?

A. 179 L

B. 692 L

C. 747 L

D. 911 L

19 The decomposition of mercury oxide into its elemental components occurs via an endothermic reaction.

$$2\ HgO(s) + \rightarrow 2\ Hg(l) + O_2(g)$$

Which of the following correctly describes the spontaneity of this reaction?

A. spontaneous at all temperatures

B. spontaneous at low temperatures

C. spontaneous at high temperatures

D. non-spontaneous at all temperatures

20 An investigation was carried out using a 'coffee-cup' calorimeter to determine the molar enthalpy of dissolution of ammonium chloride. In this experiment the student dissolved 23.5 g of ammonium chloride in 200 mL of water and found that the temperature of the resultant solution dropped by 8 degrees.

What is the molar enthalpy of dissolution of ammonium chloride?

A. + 6.7 kJ mol^{-1}

B. + 7.5 kJ mol^{-1}

C. + 15.2 kJ mol^{-1}

D. + 17.0 kJ mol^{-1}

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JRAHS Chemistry Examination 2020 **Student Number**……

Mark……

Section I

Multiple Choice Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ○
10.	A ○	B ○	C ○	D ○
11.	A ○	B ○	C ○	D ○
12.	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19.	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○

Section II – 40 marks

Attempt Questions 21 – 29

Allow about 1 hours and 30 minutes for this section

- Answer all questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering and direct the examiner to your answer.

Question 21 (4 marks)

Nickel forms a compound that contains nickel (34.4 %), carbon (28.1 %) and oxygen (37.5 %). The compound boils at 45 ^{o}C. For one mole of this compound, the density of its vapour at 127 ^{o}C and 300 kPa is 30.8 g L^{-1}.

(a) Determine the empirical formula of the compound. **1**

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(b) Calculate the molar mass of the compound. **3**

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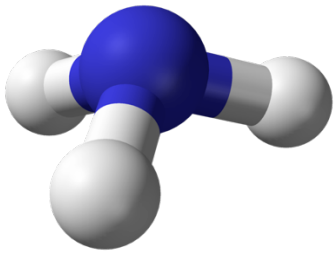
Question 22 (5 marks)

A model of an ammonia molecule is given below.



(a) What is the shape of the molecule of ammonia? 1

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(b) Draw a Lewis dot diagram for the ammonia molecule in the space provided. 1

(c) Explain the solubility of ammonia in water. Draw a labelled diagram showing intermolecular forces to support your explanation **3**

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Question 23 (4 marks)

Silicon dioxide has a melting point of 1700 ºC while carbon dioxide has a melting point of –57 ºC.

Explain how the bonding in these two compounds accounts for the different melting points **4**

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Question 24 (6 marks)

Neutralisation reactions can be carried out using standard solutions.

(a) Write a balanced equation for the reaction of nitric acid with sodium carbonate solution. **1**

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(b) Calculate the mass of sodium carbonate required to prepare 250 mL of 0.10 mol L^{-1} solution of sodium carbonate. **2**

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(c) 28.55 mL of the solution in part (b) was used to neutralise 25.00 mL of nitric acid.

Calculate the concentration of the acid. **2**

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(d) Calculate the concentration of nitrate ions in the final solution. **1**

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Question 25 (6 marks)

A galvanic cell can be constructed using two beakers, 1.0 mol L^{-1} solutions of silver nitrate and nickel chloride, silver and nickel electrodes, and a salt bridge made of filter paper.

(a) Draw and label a diagram of the galvanic cell constructed using these materials including the anode, the cathode and the direction of electron flow on the diagram. **4**

(b) Why is a salt bridge used in the galvanic cell and name a suitable compound that could be used in the salt bridge. **2**

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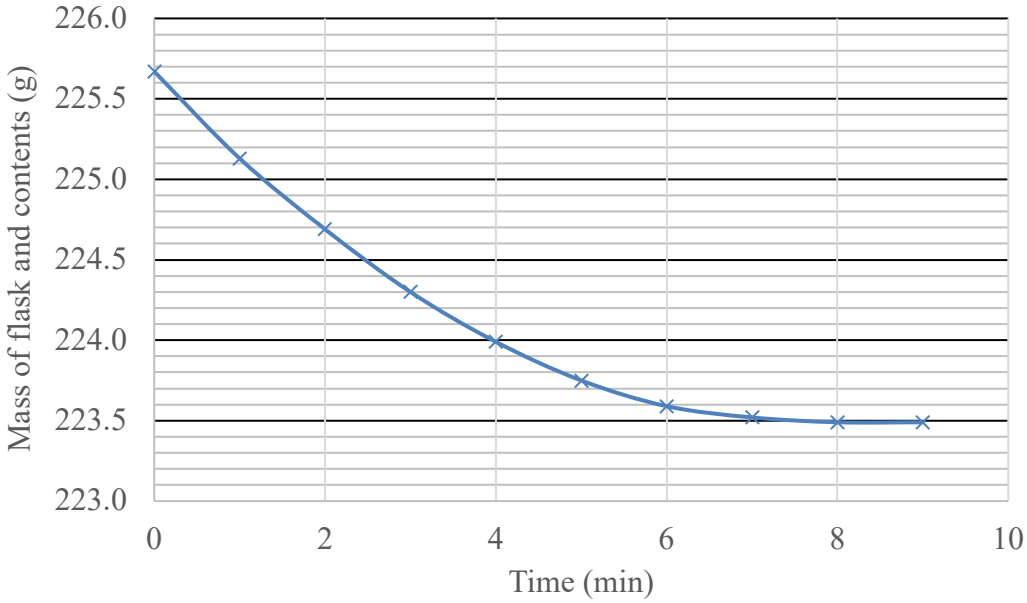
Question 26 (4 marks)

A student conducts an experiment to determine the rate of reaction between dilute hydrochloric acid and marble chips (calcium carbonate). They add 100 mL of 1.00 mol L^{-1} hydrochloric acid to a beaker and places this on a mass balance. Then they add 10.0 g of small pieces of calcium carbonate to the hydrochloric acid and records the mass every minute for 10 minutes. The results of this experiment are graphed below.



(a) Calculate the rate of reaction between:

(i) 1 – 2 minutes **1**

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(ii) 5 – 6 minutes **1**

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(b) Use collision theory to explain the changes to the rate of reaction over the 10 minutes. **2**

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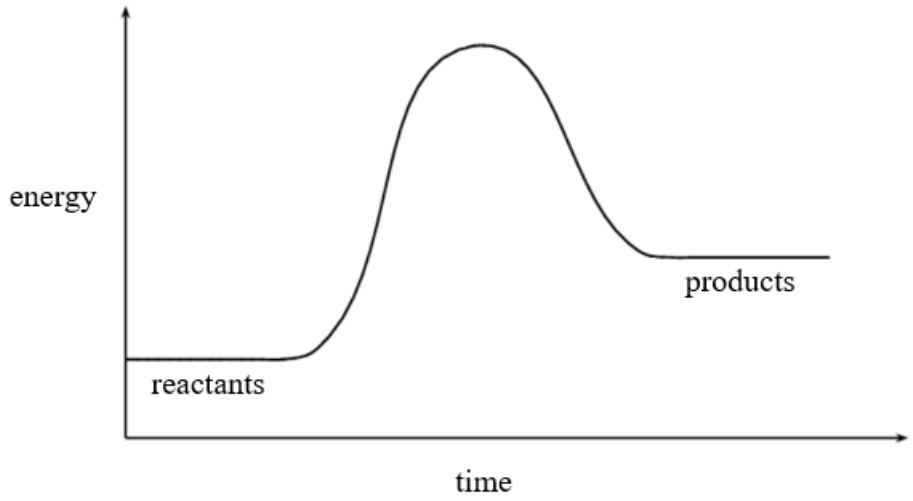
Question 27 (3 marks)

The energy profile diagram below illustrates the changes in energy that take place for a particular chemical reaction without the use of a catalyst.



(a) On the diagram above, draw the energy profile for this reaction with a catalyst. **1**

(b) Explain the effect of a catalyst on this reaction with reference to the diagram. **2**

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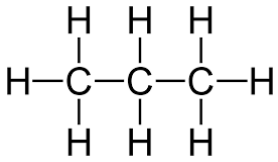
Question 28 (3 marks)

Propane is a highly flammable substance that is normally used to fuel barbecue grill tops. In this instance it undergoes complete combustion to produce carbon dioxide and water.

$$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (l)$$

The structure of propane and the table of standard bond enthalpies are provided.



Bond	Enthalpy (kJ mol^{-1})
C – C	348
C = C	614
C – H	413
C – O	358
C = O	799
H – O	463
O – O	146
O = O	495

Calculate the enthalpy of reaction. **3**

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Question 29 (5 marks)

A wide range of chemical reactions take place in the combustion chamber of car engines. One such reaction occurs between the nitrogen and oxygen gases present that leads to the production of nitrogen monoxide.

$$N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$$

This reaction was reproduced at standard conditions and the following values were obtained.

ΔH	+ 180.5 kJ mol^{-1}
ΔS	+ 24.77 J mol^{-1} K^{-1}

(a) Calculate the Gibbs free energy for the above reaction at 298 K. **2**

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(b) Explain the effect of enthalpy and entropy on the spontaneity of this reaction. **3**

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End of Examination

Part B extra writing space

If you use this space, clearly indicate which question you are answering.

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2020

JAMES RUSE AGRICULTURAL HIGH SCHOOL

YEAR 11 EXAMINATION

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General Instructions

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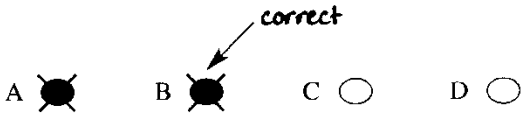

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C. $Ca(s) + 2\ H_2O(aq) \rightarrow Ca(OH)_3(l) + H_2(g)$

D. $\mathbf{Ca(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)}$

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Determine the percentages of the two isotopes of Boron given the relative atomic mass is 10.81.

	Boron-10	*Boron-11*
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D. $\Delta H_{formation}$ ($C_6H_{12}O_6$)

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B.	hydrogen	no gas produced	carbon dioxide	carbon dioxide and hydrogen
C.	carbon dioxide	carbon dioxide	hydrogen	no gas produced
D.	**hydrogen**	**no gas produced**	**carbon dioxide**	**carbon dioxide**

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A. 3.00 g L^{-1}

B. 0.0088 mol L^{-1}

C. 0.0175 mol L^{-1}

D. 1.50 g L^{-1}

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What is the correct spdf notation for X in this compound?

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B. $1s^2\ 2s^2\ 2p^6\ 3s^2$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

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What isotope does it decay into?

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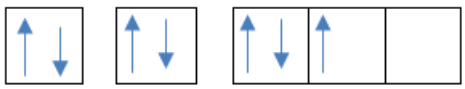
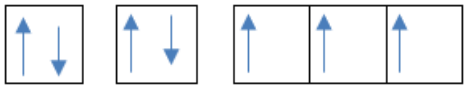
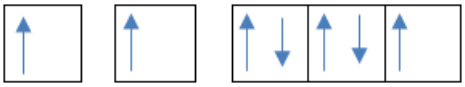
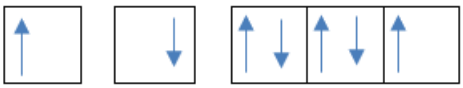
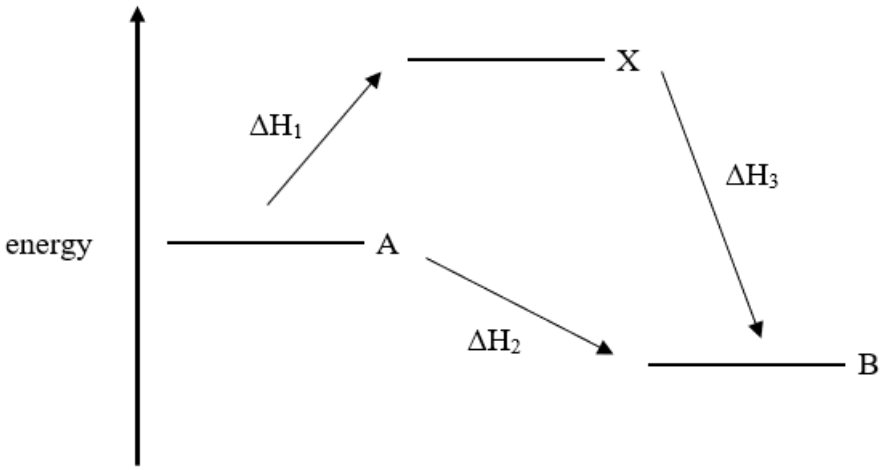
A. 

B. 

C. 

D. 

15 The energy cycle diagram shown below represents the conversion of reactants, A into products, B. This chemical reaction can occur directly from reactants to products or via intermediate, X.



Which of the following statements correctly demonstrates Hess' law?

A. $\Delta H_1 = \Delta H_2 + \Delta H_3$

B. $\Delta H_3 = \Delta H_1 + \Delta H_2$

C. $\mathbf{\Delta H_2 = \Delta H_1 + \Delta H_3}$

D. $\Delta H_1 = \Delta H_3 - \Delta H_2$

16 The following equation represents the reaction occurring inside a car battery.

$$a\ Pb(s) + b\ PbO_2(s) + c\ H_2SO_4(aq) \rightarrow d\ PbSO_4(s) + e\ H_2O(l)$$

The stoichiometric values for a, b, c, d and e in the equation are:

A. 1, 1, 1, 2, 2

B. 1, 1, 2, 2, 2

C. 2, 2, 2, 2, 1

D. 1, 1, 1, 1, 2

17 The following reduction couples and their E^0 values have been taken from a table of standard reduction potentials.

Reduction couples	*E^o (V)*
Co^{2+} / Co	–0.28
Cu^{2+} / Cu	0.34
Mn^{2+} / Mn	–1.18
Ru^{2+} / Ru	0.46

Which would be the correct order of reactivity if the metals are ranked in order of decreasing electrochemical reactivity?

A. Co > Mn > Cu > Ru

B. Ru > Cu > Co > Mn

C. Mn > Ru > Cu > Co

D. Mn > Co > Cu > Ru

18 A weather balloon contains 55 L of helium gas. This is released at sea level where the conditions are 105 kPa and 23 ^{o}C.

What is the change in volume of the weather balloon when it reaches its maximum altitude where the conditions are 7 kPa and –5 ^{o}C?

A. 179 L

B. 692 L

C. 747 L

D. 911 L

19 The decomposition of mercury oxide into its elemental components occurs via an endothermic reaction.

$$2\ HgO(s) + \rightarrow 2\ Hg(l) + O_2(g)$$

Which of the following correctly describes the spontaneity of this reaction?

A. spontaneous at all temperatures

B. spontaneous at low temperatures

C. spontaneous at high temperatures

D. non-spontaneous at all temperatures

20 An investigation was carried out using a 'coffee-cup' calorimeter to determine the molar enthalpy of dissolution of ammonium chloride. In this experiment the student dissolved 23.5 g of ammonium chloride in 200 mL of water and found that the temperature of the resultant solution dropped by 8 degrees.

What is the molar enthalpy of dissolution of ammonium chloride?

A. + 6.7 kJ mol^{-1}

B. + 7.5 kJ mol^{-1}

C. + 15.2 kJ mol^{-1}

D. + 17.0 kJ mol^{-1}

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JRAHS Chemistry Examination 2020 **Student Number**.....

Mark.....

Section I

Multiple Choice Answer Sheet

1.	A ○	B ●	C ○	D ○
2.	A ●	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ●
4.	A ●	B ○	C ○	D ○
5.	A ○	B ●	C ○	D ○
6.	A ○	B ○	C ○	D ●
7.	A ○	B ○	C ●	D ○
8.	A ●	B ○	C ○	D ○
9.	A ○	B ○	C ○	D ●
10.	A ○	B ○	C ○	D ●
11.	A ○	B ○	C ●	D ○
12.	A ●	B ○	C ○	D ○
13	A ○	B ●	C ○	D ○
14.	A ○	B ●	C ○	D ○
15.	A ○	B ○	C ●	D ○
16.	A ○	B ●	C ○	D ○
17.	A ○	B ○	C ●	D ○
18.	A ○	B ●	C ○	D ○
19.	A ○	B ○	C ●	D ○
20.	A ○	B ○	C ●	D ○

Section II – 40 marks

Attempt Questions 21 – 29

Allow about 2 hours and 25 minutes for this section

- Answer all questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering and direct the examiner to your answer.

Question 21 (4 marks)

Nickel forms a compound that contains nickel (34.4 %), carbon (28.1 %) and oxygen (37.5 %). The compound boils at 45 °C. For one mole of this compound, the density of its vapour at 127 °C and 300 kPa is 15.4 g L^{-1}.

(a) Determine the empirical formula of the compound. **1**

Sample answer:

	%	/MM			/ lowest number	
Ni	34.4	/58.69	=	0.586	/0.586	= 1
C	28.1	/12.01	=	2.34	/0.586	= 4
O	37.5	/16	=	2.34	/0.586	= 4

Empirical formula is Ni C_4 O_4

Marking Criteria	*Mark(s)*
• Correctly calculates the empirical formula	1

(b) Calculate the molar mass of the compound. **3**

Sample answer:

$PV = nRT$

$V = nRT/P = \frac{1 \times 8.314 \times (127 + 273)}{300}$

$= 11.085$ L

Molar mass = 11.085 x 15.4 = 170.7 g

Marking Criteria	*Mark(s)*
• Correctly calculates molar mass showing all relevant working	3
• Most relevant working shown	2
• Some relevant working	1

Question 22 (6 marks)

A model of an ammonia molecule is given below.

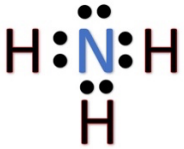
(a) What is the shape of the molecule of ammonia? 1

Sample answer: Pyramidal

Marking Criteria	*Mark(s)*
• Correctly identifies the shape	1

(b) Draw a Lewis dot diagram for the ammonia molecule in the space provided. 1

Sample answer:

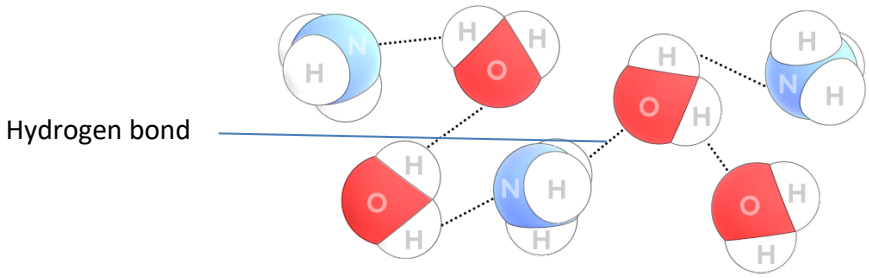


Marking Criteria	*Mark(s)*
• Correctly draws the Lewis dot diagram	1

(c) Explain the solubility of ammonia in water. Draw a labelled diagram showing intermolecular forces to support your explanation **4**

Sample answer:

Ammonia will dissolve in water as it is polar, and forms hydrogen bonds with the water molecules. The negative nitrogen end of the ammonia will form an intermolecular hydrogen bond with eth positive hydrogen end of the water molecule.



Marking Criteria	*Mark(s)*
• Correctly identifies the polar nature of ammonia and water • Outlines the hydrogen bonding • Draws a labelled diagram showing the hydrogen bonding	4
• Outlines the solubility of ammonia in water • Draws a relevant diagram	3
• Outlines the solubility of ammonia in water	2
• Gives some relevant information	1

Question 23 (4 marks)

Silicon dioxide has a melting point of 1700 ^{o}C while carbon dioxide has a melting point of –57 ^{o}C.

Explain how the bonding in these two compounds accounts for the different melting points? **4**

Sample answer:

Silicon dioxide is a network covalent substance. With covalent bonds throughout the crystal lattice, a lot of energy is required to break all the bonds and therefore the melting point is very high.

Carbon dioxide is covalent molecular with only weak dispersion forces between the molecules. These are easily overcome so the melting point is low.

Marking Criteria	*Mark(s)*
• Explains the bonding and boiling point in both substances	4
• Outlines the relationships between bonding and boiling point	3
• Outlines a relationship between bonding and boiling point	2
• Gives some relevant information	1

Question 24 (6 marks)

Neutralisation reactions can be carried out using standard solutions.

(a) Write an equation for the reaction of hydrochloric acid with sodium carbonate solution. **1**

Sample answer:

$$2\ HCl\ (aq) + Na_2CO_3\ (aq) \rightarrow 2\ NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$$

Marking Criteria	*Mark(s)*
• Correct balanced equation	1

(b) Calculate the mass of sodium carbonate required to prepare 250 mL of 0.10 mol L^{-1} solution of sodium carbonate. **2**

Sample answer:

Mol Na_2CO_3 required = c x V = 0.10 x 0.25 = 0.025 mol
Mass Na_2CO_3 required = mol x MM = 0.025 x (2(22.99) + 12.01 + 3(16)) = 2.65 g

Marking Criteria	*Mark(s)*
• Correctly calculates the mass showing all relevant working	2
• Some working shown	1

(c) 28.55 mL of this solution was used to neutralise 25.00 mL of hydrochloric acid.

Calculate the concentration of the acid. **2**

Sample answer:

Mol Na_2CO_3 = c x V = 0.1 x 0.02855 = 0.002855 mol
Therefore mol HCl = 2 x 0.002855 = 0.00571 mol
[HCl] = n/V = 0.00571/0.025 = 0.228 mol L^{-1}

Marking Criteria	*Mark(s)*
• Correctly calculates the concentration showing all relevant working	2
• Some working shown	1

(d) Calculate the concentration of chloride ions in the final solution. **1**

Sample answer:

$[Cl^-]$ = mol/V = 0.00571/ 0.02855 +0.025 = 0.107 mol L^{-1}

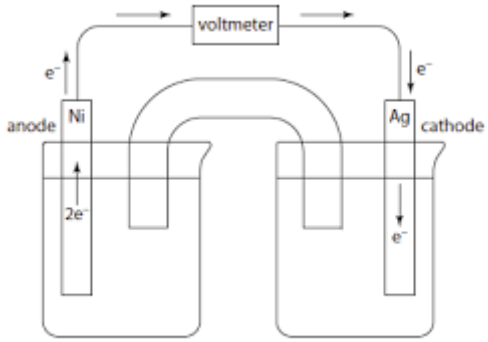
Marking Criteria	*Mark(s)*
• Correctly calculates the concentration showing all relevant working	1

Question 25 (6 marks)

A galvanic cell can be constructed using 2 beakers, 1.0 mol L^{-1} solutions of silver nitrate and nickel chloride, pieces of silver and nickel metal, and a salt bridge and filter paper.

(a) Draw and label a diagram of the galvanic cell constructed from this material. Clearly label the anode, the cathode and the direction of electron flow on the diagram. **4**

Sample answer:



Marking Criteria	*Mark(s)*
• Correctly drawn and labelled diagram of galvanic cell showing anode, cathode, direction of electron flow, correct metal in each solution. Neat and clear diagram	4
• One component missing or incorrectly labelled or unclear diagram	3
• Two components missing or incorrectly labelled or unclear diagram	2
• One correct component or label in a diagram	1

(b) Why is a salt bridge used in the galvanic cell and name a suitable compound that could be used in the salt bridge. **2**

Sample answer:

A salt bridge allows ions to flow between the two half-cells and so electrons can flow in the external circuit. KNO_3 would be a suitable salt solution for the salt bridge as it does not react with any of the other chemicals.

Marking Criteria	*Mark(s)*
• Correct explanation of use of salt bridge and correct identification of a suitable compound that could be used as a salt bridge	2
• Correct explanation of use of salt bridge or correct identification of a suitable compound that could be used as a salt bridge	1

Question 26 (4 marks)

A student conducts an experiment to determine the rate of reaction between dilute hydrochloric acid and marble chips (calcium carbonate). They adds 100 mL of 1.00 mol L^{-1} hydrochloric acid to a beaker and places this on a mass balance. Then they add 10.0 g of small pieces of calcium carbonate to the hydrochloric acid and records the mass every minute for 10 minutes. The results of this experiment are graphed below.

(a) Calculate the rate of reaction between:

(i) 1 – 2 minutes **1**

Sample answer: 0.44 g min^{-1}

(ii) 5 – 6 minutes **1**

Sample answer: 0.16 g min^{-1}

Marking Criteria	*Mark(s)*
• Two correct calculations for rates with correct units	2
• Any one error in calculation or incorrect units	1

(b) Explain the changes to the rate of reaction over the 10 minutes. **2**

Sample answer:

The rate of the reaction decreases with time as the acid reacts the concentration of HCl decreases.

Marking Criteria	*Mark(s)*
• Correct explanation for the changes in rate of reaction over time	2
• Correct description of the changes in rate of reaction over time	1

Question 27 (2 marks)

The energy profile diagram below illustrates the changes in energy that take place for a particular chemical reaction without the use of a catalyst.

Explain the effect of a catalyst on this reaction with reference to the energy profile diagram. **2**

Sample answer:

A catalyst provides an alternative pathway for the chemical reaction to proceed which involves a lower activation energy. This would be seen on the energy profile diagram as a decrease in the height of the peak.

Marking Criteria	*Mark(s)*
• Correct explanation for the effect of a catalyst and reference to the reduction in height of the energy profile curve.	2
• Provides some relevant information.	1

Question 28 (3 marks)

Propane is a highly flammable substance that is normally used to fuel barbecue grill tops. In this instance it undergoes complete combustion to produce carbon dioxide and water.

$$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (l)$$

The structure of propane and the table of standard bond enthalpies are provided.

Calculate the enthalpy of reaction. **3**

Sample answer:

$\Delta H_{rxn} = \Sigma_{\Delta H}$(bonds broken) – $\Sigma_{\Delta H}$(bonds formed)
= (348 x 2 + 413 x 8 + 495 x 5) – (799 x 6 + 463 x 8)
= 6475 – 8498
ΔH_{rxn} = – 2023 kJ mol^{-1}

Marking Criteria	*Mark(s)*
• Correctly calculates enthalpy of reaction showing all relevant working	3
• Most relevant working shown	2
• Some relevant working	1

Question 29 (5 marks)

A wide range of chemical reactions take place in the combustion chamber of car engines. One such reaction occurs between the nitrogen and oxygen gases present that leads to the production of nitrogen monoxide.

$$N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$$

This reaction was reproduced at standard conditions and the following values were obtained.

(a) Calculate the Gibbs free energy for the above reaction at 298 K. **2**

Sample answer:

$\Delta G = \Delta H - T\Delta S = +180.5 - 298 \times (24.77 / 1000) = +173.1$ kJ mol^{-1}

Marking Criteria	*Mark(s)*
• Correctly calculates the Gibbs free energy showing all relevant working	2
• Some working shown	1

(b) Explain the effect of enthalpy and entropy on the spontaneity of this reaction. **3**

Sample answer:

Since the entropy value for this reaction is positive, the reaction is considered to be entropy driven as this will contribute towards a negative value for the Gibbs free energy and contribute towards a spontaneous reaction. However, the enthalpy value of this reaction is also positive, which does not contribute towards a negative value for the Gibbs free energy and in turn contributes towards making this reaction non-spontaneous. Since the magnitude of the enthalpy value is greater, the entropy drive is unable to overcome this and results in a non-spontaneous reaction overall.

Marking Criteria	*Mark(s)*
• Explains the individual contributions of enthalpy and entropy and their link to spontaneity. • Explains that the difference in magnitude accounts for the overall non-spontaneous nature of the reaction.	3
• Describes the individual contributions of enthalpy and entropy and their link to spontaneity.	2
• Provides some relevant information	1

End of Examination