Student Number…………………….

Mark …………………………………..

James Ruse Agricultural High School

Theory

Year 11 Preliminary Chemistry Exam 2010

General Instructions

Total Marks   52

- **Reading Time**:   5 minutes
- **Working Time**:   50 minutes
- Write using black or blue pen
- Board approved calculators may be used
- Write your Student Number at the top of this page
- A Periodic Table and Data sheet are attached to the back of the paper. This may be removed for your convenience.

Part A

Multiple Choice: 11 marks
Attempt Questions 1-11
Allow about 10 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.

correct

A ✖   B ✖   C ◯   D ◯

▸ **Mark your answers for Questions 1 – 11 in the Answer Box on page 9**

1.   Which of the following properties of water cannot be explained by intermolecular forces?

(A)   bent shape

(B)   surface tension

(C)   viscosity

(D)   boiling point

2.   When the chloride of the ion A^{2+} is added to a solution of sodium sulfate, a white precipitate forms. Which of the following statements describes the system most accurately?

(A)   A saturated solution of NaCl is present.

(B)   A saturated solution of ASO_4 is present.

(C)   An unsaturated solution of ASO_4 is present.

(D)   A saturated solution of ACl is present.

3.   Water can wet cellulose but it cannot dissolve it. Which of the following characteristics of water and/or of cellulose explains this?

(A)   Water is not polar enough to dissolve cellulose.

(B)   Cellulose cannot hydrogen bond with water extensively enough.

(C)   Hydrogen bonding between cellulose strands is stronger than hydrogen bonding between water and cellulose.

(D)   Hydrogen bonding between water molecules is stronger than the hydrogen bonding between water and cellulose.

4. If the mercury level in a certain variety of fish is 0.50 ppm. What mass of fish of the same variety would you have to eat to ingest a total of 100 mg mercury?

(A) 2.0×10^5 grams

(B)   2.0 kilograms

(C)   5.0 kilograms

(D) 5.0×10^2 grams

5. The specific capacity of various solvents are given in the table.

Substance	Specific Heat Capacity $(J\,K^{-1}g^{-1})$
water	4.18
ethanol	2.44
ethylene glycol	2.39
acetone	2.17

A certain amount of heat is applied to 100 g of water resulting in a temperature increase of 5 ^{0}C. If the same amount of heat is applied to ethylene glycol to obtain the same temperature increase, what mass of ethylene glycol will be required?

(A)   175 g

(B)   57 g

(C)   137 g

(D)   238 g

6.   Various forces exist between atoms in molecules and between molecules such as

         (i)   covalent bonding
         (ii)   hydrogen bonding
         (iii)   dipole-dipole interaction
         (iv)   dispersion forces

         Which of these forces exist between solute and solvent molecules in a solution of CHF_3 in CH_3CH_2OH?

(A)   (i), (ii), (iii), (iv)

(B)   (ii), (iii) and (iv) only

(C)   (iii) and (iv) only

(D)   (iv) only

7.   Which statement below is equal to one mole of any substance ?

(A) 6.02×10^{-23}

(B)   The number of carbon atoms in exactly 12.000 g of carbon-12.

(C)   The number of hydrogen molecules in 1.00 g of hydrogen.

(D)   1/3 the number of oxygen atoms in 100.09 g of calcium carbonate.

8. $3Zn_{(s)} + 2\,Fe(NO_3)_{3(aq)} \rightarrow 3Zn(NO_3)_{2(aq)} + 2Fe_{(s)}$
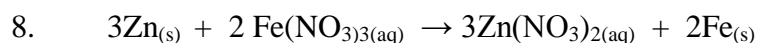
         Which statement best describes the useful information provided by the equation ?

(A)   3 zinc atoms reacts 2 iron(III) nitrate molecules.

(B)   3 grams of zinc react with 2 g of iron (III) nitrate.

(C)   3 zinc molecules react with 2 iron(III) nitrate molecules.

(D)   3 moles of zinc react with 2 moles of iron (III) nitrate.

9.   Which of the following statements is true for the combustion of any element or compound ?

(A)   Heat is a reactant.

(B)   Heat is absorbed from the surroundings.

(C)   Heat is released to the surroundings..

(D)   Heat energy is converted to chemical energy.

10.   The table shows the method and results of four experiments.

Method	Results
Liquid hexane was slowly heated	The liquid disappeared
Blue copper(II) sulfate crystals were heated	White crystals formed which turned blue as it cooled
Sodium Chloride was added to water	The solid disappeared
Carbon dioxide was added to limewater	A white solid formed

Which results give an indication of a chemical reaction ?

(A)   The solid disappeared

(B)   The liquid disappeared

(C)   White solid formed

(D)   White crystals turned blue

11. This is the energy profile diagram for a reversible reaction
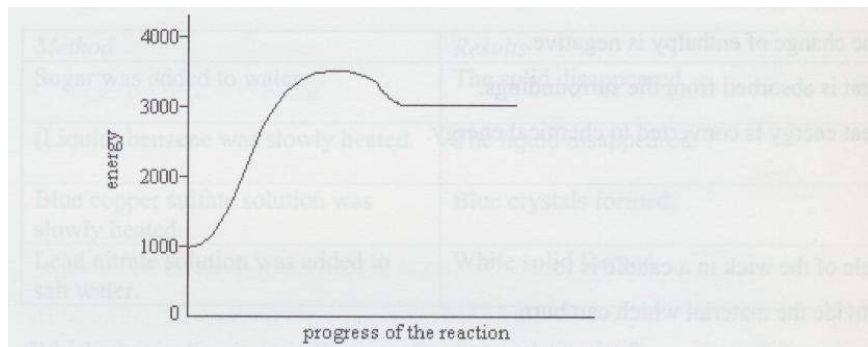
The activation energy for the endothermic reaction is
(A)   500 kJ

(B)   2000 kJ

(C)   2500 kJ

(D)   3500 kJ

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Part A: Answer grid for multiple choice questions

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

4. A O   B O   C O   D O

5. A O   B O   C O   D O

6. A O   B O   C O   D O

7. A O   B O   C O   D O

8. A O   B O   C O   D O

9. A O   B O   C O   D O

10. A O   B O   C O   D O

11. A O   B O   C O   D O

Marks:

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Part B.   41 marks
Attempt Questions 12 - 20
Allow about 40 minutes for this part
▶ *Show all relevant working in questions involving calculations.*

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Question 12. (6 marks)

The table shows the boiling point for water, methane, hydrogen sulfide and ammonia.

Substance	*Boiling point, ^oC*
ammonia	-33
hydrogen sulfide	-62
water	100
methane	-161

(a)   Using Lewis electron dot diagrams, explain the molecular shapes and polarity of these three substances. (3 marks)

ammonia	hydrogen sulfide	water	methane

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(b)   Using molecular shapes and any other factors you think are significant, explain the boiling points of the four substances. (3 marks)

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Question 13 (2 marks)

Explain how water is used in measuring energy changes in chemical reactions.

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Question 14 (3 marks)

Discuss the implications for organisms if a lake is affected by thermal pollution.

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Question 15 (7 marks)

(a)   Calculate the molarity of a solution prepared by dissolving 0.345 g calcium chloride in enough water and diluting to 250.00 mL. (2 marks)

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(b)   What is the concentration of the chloride ion in (a) in %(w/v)?   (2 marks)

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(c)   If 10.0 mL of a 0.3 mol L^{-1} sodium carbonate is added to 100.0 mL of the solution in (a), what mass of precipitate is obtained? (3 marks)

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Question 16. (4 marks)

A 9.54 g of a compound containing only copper and oxygen was converted into copper metal by a reduction process involving hydrogen gas. The mass of the copper that formed from the reaction was 7.62 g.

(a)   Determine the empirical formula for the compound.   (3 marks)
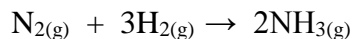
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(b)   Identify the systematic name of the compound.   (1 mark)

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Question 17 (4 marks)

Ammonia can be formed by the reaction

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

A mixture of 50 mL of nitrogen and 120 mL of hydrogen is reacted completely.

(a)   Calculate the volume of the three gases remaining after the reaction. All volumes are measured at the same temperature and pressure.   (3 marks)

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(b)   Name the chemical law used in the calculation above.   (1 mark)

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Question 18 (3 marks)

Pentanol burns completely in oxygen according to the equation

$$2C_5H_{11}OH_{(l)} \quad + \quad 15O_{2(g)} \quad \rightarrow \quad 10CO_{2(g)} \quad + \quad 12H_2O_{(l)}$$
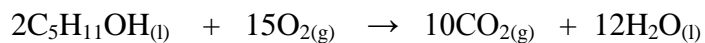
If 96 L of carbon dioxide is formed at 25^0C and 100 kPa, calculate the mass of pentanol used in the reaction.

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Question 19 (5 marks)

Petrol contains octane, C_8H_{18}, as one of its main constituents. Under certain conditions poisonous gases can be released during the combustion of octane in an internal combustion engine. For example, the incomplete combustion of the fuel can result in the release of toxic gases.

(a)   What could cause the incomplete combustion of octane ?   (1 mark)

....

(b)   Write a balanced chemical equation for a reaction which releases poisonous gases during the combustion of octane.   (1 mark)

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(c)   Explain why the energy released when one mole of octane combusts to produce toxic gases is significantly lower than the heat of combustion for octane.   (2 marks)

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(d)   State one characteristic of the reaction in which octane is combusted that makes it suitable for use in an internal combustion engine.   (1 mark)

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Question 20 (7 marks)

Nitrogen monoxide was reacted with molecular oxygen to give nitrogen dioxide gas.
The rate of the reaction was measured by determining the change in nitrogen monoxide
concentration with time at a fixed temperature.
The experimental data is tabulated below :

Time(s)	0	10	20	30	40	50
Nitrogen monoxide concentration ($\times 10^{-4}$ molL^{-1})	5.0	3.8	3.2	2.8	2.4	2.0

(a)   Draw a line graph of this data. Plot time on the horizontal axis   (4 marks)
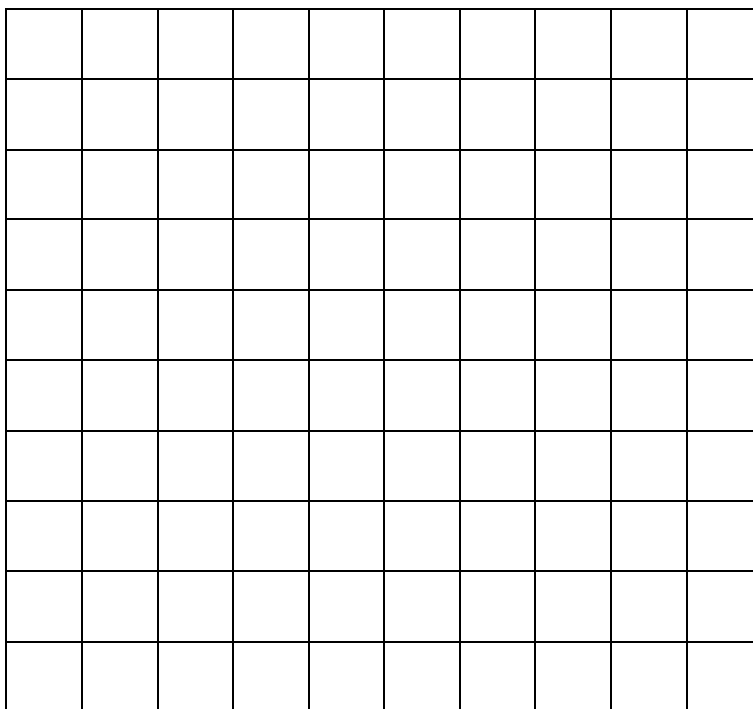
(c)   Explain how the reaction rate changes with time.   (3 marks)

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End of Test

Year 11 Chemistry Yearly Answers 2010

Part A: Answer grid for multiple choice questions

1.   A √   B **O**   C **O**   D **O**

2.   A **O**   B √   C **O**   D **O**

3.   A **O**   B **O**   C √   D **O**

4.   A√   B **O**   C **O**   D **O**

5.   A √   B **O**   C **O**   D **O**

6.   A **O**   B **O**   C √   D **O**

7.   A **O**   B √   C **O**   D **O**

8.   A **O**   B **O**   C **O**   D √

9..   A **O**   B **O**   C√   D **O**

10.   A **O**   B **O**   C√   D **O**

11.   A **O**   B **O**   C√   D **O**

Marks:

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1. Which of the following properties of water cannot be explained by intermolecular forces?
    (A)   bent shape
    (B)   surface tension
    (C)   viscosity
    (D)   boiling point

    OUTCOME(S): P13, P6

2. When the chloride of the ion A^{2+} is added to a solution of sodium sulfate, a white precipitate forms. Which of the following statements describes the system most accurately?
    (A)   a saturated solution of NaCl is present
    (B)   a saturated solution of ASO_4 is present
    (C)   an unsaturated solution of ASO_4 is present
    (D)   a saturated solution of ACl is present

    OUTCOME(S): P8, P13

3. Water can wet cellulose but it cannot dissolve it.   Which of the following characteristics of water and/or of cellulose explains this?
    (A)   water is not polar enough to dissolve cellulose
    (B)   cellulose cannot hydrogen bond with water extensively enough
    (C)   hydrogen bonding between cellulose strands is stronger than hydrogen bonding between water and cellulose
    (D)   hydrogen bonding between water molecules is stronger than the hydrogen bonding between water and cellulose

    OUTCOME(S): P7, P13

4. If the mercury level in a certain variety of fish is 0.50 ppm. What mass of fish of the same variety would you have to eat to ingest a total of 100 mg mercury?
    (A) 2.0×10^5 grams
    (B)   2.0 kilograms
    (C)   5.0 kilograms
    (D) 5.0×10^2 grams

    OUTCOME(S): P10, P13

5. The specific capacity of various solvents are given in the table.

Substance	Specific Heat Capacity $(J\,K^{-1}g^{-1})$
water	4.18
ethanol	2.44
ethylene glycol	2.39
acetone	2.17

A certain amount of heat is applied to 100 g of water resulting in a temperature increase of 5 ^{0}C. If the same amount of heat is applied to ethylene glycol to obtain the same temperature increase, what mass of ethylene glycol will be required?

(A) **175 g**
(B) 57 g
(C) 137 g
(D) 238 g

OUTCOME(S): P7, P10, P13

6. Various forces exist between atoms in molecules and between molecules such as
(i) covalent bonding
(ii) hydrogen bonding
(iii) dipole-dipole interaction
(iv) dispersion forces

Which of these forces exist between solute and solvent molecules in a solution of CHF_3 in CH_3CH_2OH?

(A) (i), (ii), (iii), (iv)
(B) (ii), (iii) and (iv) only
(C) **(iii) and (iv) only**
(D) (iv) only

OUTCOME(S): P6, P7

7. Which statement below is equal to one mole of any substance ?

(A) 6.02×10^{-23}

(B) **The number of carbon atoms in exactly 12.000 g of carbon-12.**

(C) The number of hydrogen molecules in 1.00 g of hydrogen.

(D) 1/3 the number of oxygen atoms in 100.09 g of calcium carbonate.
OUTCOME(S): P2
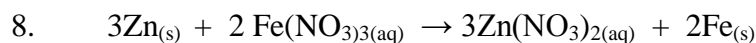
8. $3Zn_{(s)} + 2\,Fe(NO_{3)3(aq)} \rightarrow 3Zn(NO_3)_{2(aq)} + 2Fe_{(s)}$

Which statement best describes the useful information provided by the equation ?

(A) 3 zinc atoms reacts 2 iron(III) nitrate molecules.

(B) 3 grams of zinc react with 2 g of iron(III) nitrate.

(C) 3 zinc molecules react with 2 iron(III) nitrate molecules.

(D) 3 moles of zinc react with 2 moles of iron (III) nitrate.

OUTCOME(S): P6

9. Which of the following statements is true for the combustion of any element or compound ?
(A) Heat is a reactant.
(B) Heat is absorbed from the surroundings.
(C) Heat is released to the surroundings..
(D) Heat energy is converted to chemical energy.
    OUTCOME(S): P7

10. The table shows the method and results of four experiments.

Method	Results
Liquid hexane was slowly heated	The liquid disappeared
Blue copper(II) sulfate crystals were heated	White crystals formed which turned blue as it cooled
Sodium Chloride was added to water	The solid disappeared
Carbon dioxide was added to limewater	A white solid formed

Which results give an indication of a chemical reaction ?

(A) The solid disappeared
(B) The liquid disappeared
(C) White solid formed
(D) White crystals turned blue
    OUTCOME(S): P2

11.   This is the energy profile diagram for a reversible reaction
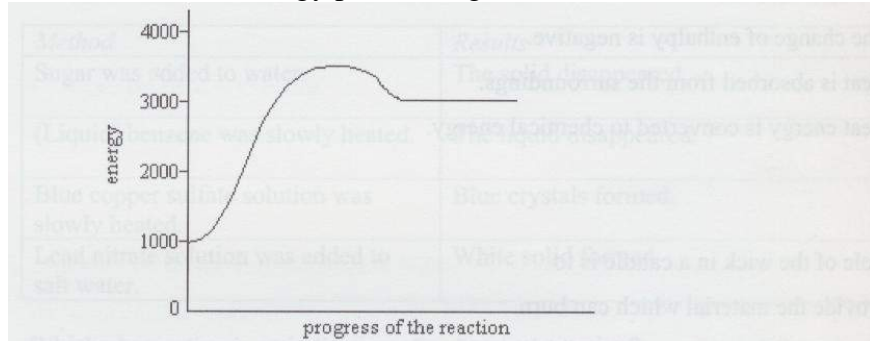
The activation energy for the endothermic reaction is
(A)   500 kJ
(B)   2000 kJ   **(C)   2500 kJ**   (D)   3500 kJ

OUTCOME(S): P8, P7

Part B Question 12. (6 marks)
The table shows the boiling point for water , hydrogen sulfide and ammonia.

Substance	Boiling point, ^{o}C
ammonia	-33
hydrogen sulfide	-62
water	100
methane	-161

(a)   Draw Lewis electron dot diagrams to explain the molecular shapes and polarity of these three substances. (3 marks)

H H : N : H ammonia	H : S : H hydrogen sulfide	H : O : H water

All three substances are unsymmetrical: ammonia is trigonal pyramidal in shape , whereas hydrogen sulfide and water are both V- shaped. Because of the unsymmetrical distribution of electrons and the greater electronegativity of oxygen and nitrogen compared with sulfur, ammonia and water are both more polar than hydrogen sulfide.

OUTCOMES: P6, P13

Criteria	Mark(s)
correct Lewis electron dot diagrams for all three substances	*2*
correct Lewis electron dot diagrams for two substances	*1*
correct Lewis electron dot diagrams one substance	*0*
correct reasoning for the differences in polarity	*1*

(b)   Using molecular shapes and any other factor you think is significant, explain the boiling points of the four substances. (3 marks)
The table shows that hydrogen sulfide has the lowest boiling point. This can be explained by its lower polarity compared with ammonia and water. This results in weaker dipole-dipole interaction between hydrogen sulfide molecules. In addition to higher polarity, both ammonia and water are able to hydrogen bond.
Hydrogen bonding is a stronger interaction than dipole-dipole interaction. The hydrogen bonding in water is stronger and much more extensive than in ammonia resulting in higher intermolecular forces between water molecules and hence higher boiling point

Criteria	Mark(s)
dipole-dipole interaction in hydrogen sulfide	*1*
hydrogen bonding present only in water and ammonia	*1*
hydrogen bonding in ammonia less extensive than that in water resulting in lower boiling point	*1*

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Question 13   (2 marks)
Explain how water is used in measuring energy changes in chemical reactions.

OUTCOME(S): P7, P8, P13
Sample answer:
Water has a very high specific heat capacity which allows it to absorb large quantities of heat
 for a small increase in temperature. The energy change can be determined using the formula,
 $q=-mc\Delta T$, where q is the total amount of heat in joules, m is the mass of the water, c is the
 specific capacity of water and ΔT, the change in the temperature.

Criteria	Mark(s)
the high heat capacity of water is mentioned	1
the formula , $q=-mc\Delta T$ is given	1

Question 14(3 marks)

Discuss the implications for organisms if a lake is affected by thermal pollution.

OUTCOME(S): P16
Sample answer:
Thermal pollution is the discharge into a river or lake of large quantities of hot water which can
 increase the temperature of the water body by 2 to $5^{o}C$.   (1 mark)
IMPLICATIONS
One implication of thermal pollution is the decrease in the amount of dissolved oxygen in the
 water. This makes the water unpleasant since anaerobic instead of aerobic decomposition of
 organic matter can result making the water unpleasant even for recreational purposes.
 Another implication is the resulting loss of diversity in the life forms in the water as only certain
 species can survive with less dissolved oxygen. This results in less variety of fish available to
 humans.

Criteria	Mark(s)
Definition of thermal pollution	1
Two implications	2
Only one implication given	1

Question 15 (7 marks)

(a)   Calculate the molarity of a solution prepared by dissolving 0.345 g calcium chloride in enough water and diluting to 250.00 mL. (2 marks)

(b)   What is the concentration of the chloride ion in (a) in %(w/v)?   (2 marks)

(c)   If 10.0 mL of a 0.3 mol L^{-1} sodium carbonate is added to 100.0 mL of the solution in (a), what mass of precipitate is obtained? (3 marks)

OUTCOME(S) P13, P10

Sample Answers:

(a)   Calculate the molarity of a solution prepared by dissolving 0.345 g calcium chloride in enough water and diluting to 250.00 mL. (2 mark)

$$[CaCl_2] = \frac{mass/molar\,mass}{V_L} = \frac{0.345/40.08+2(35.45)}{0.250} = 0.0124\,mol\,L^{-1}$$

Criterion/ia	Mark(s)
moles of CaCl$_2$ calculated	1
molarity calculated	1

(b)   What is the concentration of the chloride ion in (a) in % (w/v)   (2 marks)
Sample Answer:
$[Cl^-] = 2 \times [CaCl_2] = 2 \times 0.0124 = 0.0248\,mol\,L^{-1}$ *(1 mark)*

$\% \ w/v = [0.0248] \times 35.45 \times \dfrac{100}{250} = 0.351 \% \ (w/v)$ *(1 mark)*

(c)   If 10.00 mL of a 0.300 mol L^{-1} sodium carbonate is added to 100.00 mL of the solution in (a), what mass of precipitate is obtained? (3 marks)
Sample answer:
moles Na$_2$CO$_3$ = C x V = 0.300 x 0.0100 = 0.003 moles (1 mark)
moles CaCl$_2$ = 0.0124 x 0.100 = 0.00124 mole (limiting reagent) (1 mark)
∴ moles CaCO$_3$ = 0.00124
mass CaCO$_3$ = 0.00124 x (40.08 + 12.01 + 3 (16.00) = 0.124 grams (1 mark)

Question 16. (4 marks)

A 9.54 g of a compound containing only copper and oxygen was converted into copper metal by a reduction process involving hydrogen gas. The mass of the copper that formed from the reaction was 7.62 g.

(a)   Determine the empirical formula for the compound.   (3 marks)

(b)   Identify the systematic name of the compound.   (1 mark)

(a) Sample Answer : moles of Cu = 7.62 / 63.55 = 0.12
Moles of O = 9.54 – 7.62 / 16 = 0.12
Ratio of Cu : O   is 1:1 thus empirical formula is CuO.

(b) Copper (II) Oxide

1 a   Marking Guidelines

Marking Criteria	Mark
Correct determination of empirical formula showing calculations of moles and mole ratios of Cu : O	3
One of the above missing	2
Two of the above missing	1

1 b Marking Guidelines

Marking Criteria	Mark
Correct identification (name) of compound	1

Question 17 (4 marks)
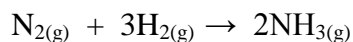
Ammonia can be formed by the reaction

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

A mixture of 50 mL of nitrogen and 120 mL of hydrogen is reacted completely.

(a)   Calculate the volume of the three gases remaining after the reaction. All volumes are measured at the same temperature and pressure.   (3 marks)

Sample Answer : The ratio of the volumes of reactants and products is $N_2 : H_2 : NH_3$
Thus 40 mL of N_2 and all the H_2 (120 mL) react, and the volume of NH_3 produced
= 80 mL . Volume of N_2 left over = 50 – 40 = 10 mL. No H_2 is left over.

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(b)   Name the chemical law used in the calculation above.   (1 mark)

    Sample Answer : Gay – Lussac's Law of Combining Gas Volumes.

21 a Marking Guideline
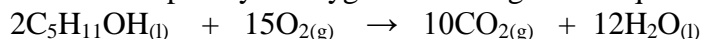
Marking criteria	Mark
Correct calculations of the three gas volumes using mole ratios and balanced equation	3
One of the above missing	2
Two of the above missing	1

21 b Marking Guideline

Marking Criteria	Mark
Correct identification of Gay-Lussac's Law	1

Question 18 (3 marks)

Pentanol burns completely in oxygen according to the equation
$$2C_5H_{11}OH_{(l)} + 15O_{2(g)} \rightarrow 10CO_{2(g)} + 12H_2O_{(l)}$$
If 96 L of carbon dioxide is formed at 25^0C and 100 kPa, calculate :
(a)   The mass of pentanol used in the reaction   (3 marks)

    Sample Answer :
    (a) Mass = 88 X 0.2 X 196 / 24.79 =

22 a Marking Guideline

Marking Criteria	Mark
Correct calculation showing all working for mass using correct RTP values	3
Any one of the above missing	2
Any two of the above missing	1

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Question 19 (5 marks)

Petrol contains octane, C_8H_{18}, as one of its main constituents. Under certain conditions poisonous gases can be released during the combustion of octane in an internal combustion engine. For example, the incomplete combustion of the fuel can result in the release of toxic gases.

(a)   What could cause the incomplete combustion of octane ?   (1 mark)

(b)   Write a balanced chemical equation for a reaction which releases poisonous gases during the combustion of octane.   (1 mark)

(c)   Explain why the energy released when one mole of octane combusts to produce toxic gases is significantly lower than the heat of combustion for octane.   (2 marks)

(d)   State one characteristic of the reaction in which octane is combusted that makes it suitable for use in an internal combustion engine.   (1 mark)

Sample Answer :
(a) Lack of oxygen (or too much fuel vapour)
(b) For example $C_8H_{18(l)}$ + $17/2\ O_{2(g)} \rightarrow 8CO_{(g)}$ + $9H_2O_{(g)}$
(c) The heat of combustion for octane (or any fuel) is measured when the fuel completely combusts in oxygen. The products formed by incomplete combustion such as CO, have a smaller number of bonds than those formed on complete combustion, such as CO_2. Formation of fewer bonds releases less energy.
(d) Combustion of octane forms product gases whose volume is greater than the reactants ; this exerts greater pressure on the pistons and cause them to move.(The heat produced also causes the gases to expand.)

23 a Marking Guideline

Marking Criteria	Mark
Identification of correct cause for incomplete combustion	1

23 b Marking Guideline

Marking Criteria	Mark
Correct balanced equation for the combustion of octane	1

23 c Marking Guideline

Marking Criteria	Mark
Detailed explanation of the reason for the lower energy released during incomplete combustion of octane	2
Brief description of the reason for the lower energy released during the incomplete combustion of octane.	1

23 d Marking Guideline

Marking criteria	Mark
One suitable characteristic for the combustion of octane	1

Question 20 (7 marks)

Sample Answers :

(a) Correct scale ; axes correctly labeled ; correct plots of points ; line(curve) of best fit

Marking Guideline

Criteria	Mark
Correct labeling of axes, suitable scale, correct plots of points, line(curve) of best fit, suitable use of space on grid for graph	4
Any one of the above missing	3
Any two of the above missing	2
Any three of the above missing	1

(b) The rate of reaction decreases with time as the slope of the graph decreases.
   This is due to the decrease in reactant (NO).

Marking Guidelines

Criteria	Mark
A correct explanation and identification of the trend in the graph	3
A description and identification of the trend in the graph	2
An identification of the trend in the graph	1

Outcomes P2, P8, P13