Student Number	
Mark / 40	

Chemistry

2018 Term 4

Working Scientifically

General Instructions

- Reading time - 5 minutes
- Working time – 70 minutes
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formulae sheet, data sheet and Periodic Table are provided
- Answer questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations
- Extra working space is provided at the back of the exam booklet. If you use this space, clearly indicate which question you are answering.

One section - 40 marks
Attempt questions 1-3

Question 1 (15 marks)

A student designed an experiment to find out which brand of detergent was the most concentrated. More expensive brands made claims that they were more concentrated than cheaper brands. The more concentrated the detergent was, the less would be needed for washing. The manufacturers of the expensive brands claimed that their detergents were better value for money then cheaper brands.
The student's report is below.

Aim

I tested 6 brands of detergent and found out how much water they contained. Then I compared their prices, so I could say which was the best value for money.

Equipment

6 clean evaporating basins
Electronic balance
Drying oven

Method

1. *I made sure the evaporating basins were clean, so I washed the dirty ones first.*
2. *Then I poured 20 mL of each detergent in a labelled evaporating basin.*
3. *I weighed each evaporating basin and put them in the drying oven.*
4. *3 days later I weighed them again and worked out how much water evaporated.*

Results

Detergent	*Starting weight of basin and detergent (g)*	*Final weight of basin and detergent (g)*	*Weight of water lost (g)*	*Price ($)*
Fresh	*149.4*	*132.2*	*17.2*	*5.99*
Sparkle	*154.5*	*137.6*	*16.9*	*6.11*
Golden Glow	*155.9*	*140.6*	*15.3*	*6.89*
Lemon Scent	*148.3*	*131.2*	*17.1*	*6.05*
Morning Mist	*149.8*	*132.3*	*17.5*	*6.25*
Magic Muscle	*146.7*	*130.8*	*15.9*	*6.34*

Conclusion

Golden Glow was the brand of detergent that lost the least water. It must have been the most concentrated. It was also the most expensive, so it was the best value for money.

(a) Suggest a more appropriate *aim* for this experiment. **1**

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(b) Rewrite the student's method using the appropriate language for a scientific report. **4**

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(c) Discuss the original method with respect to reliability and validity. **4**

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(d) Describe three changes you would make to the method to improve this experiment. **6**

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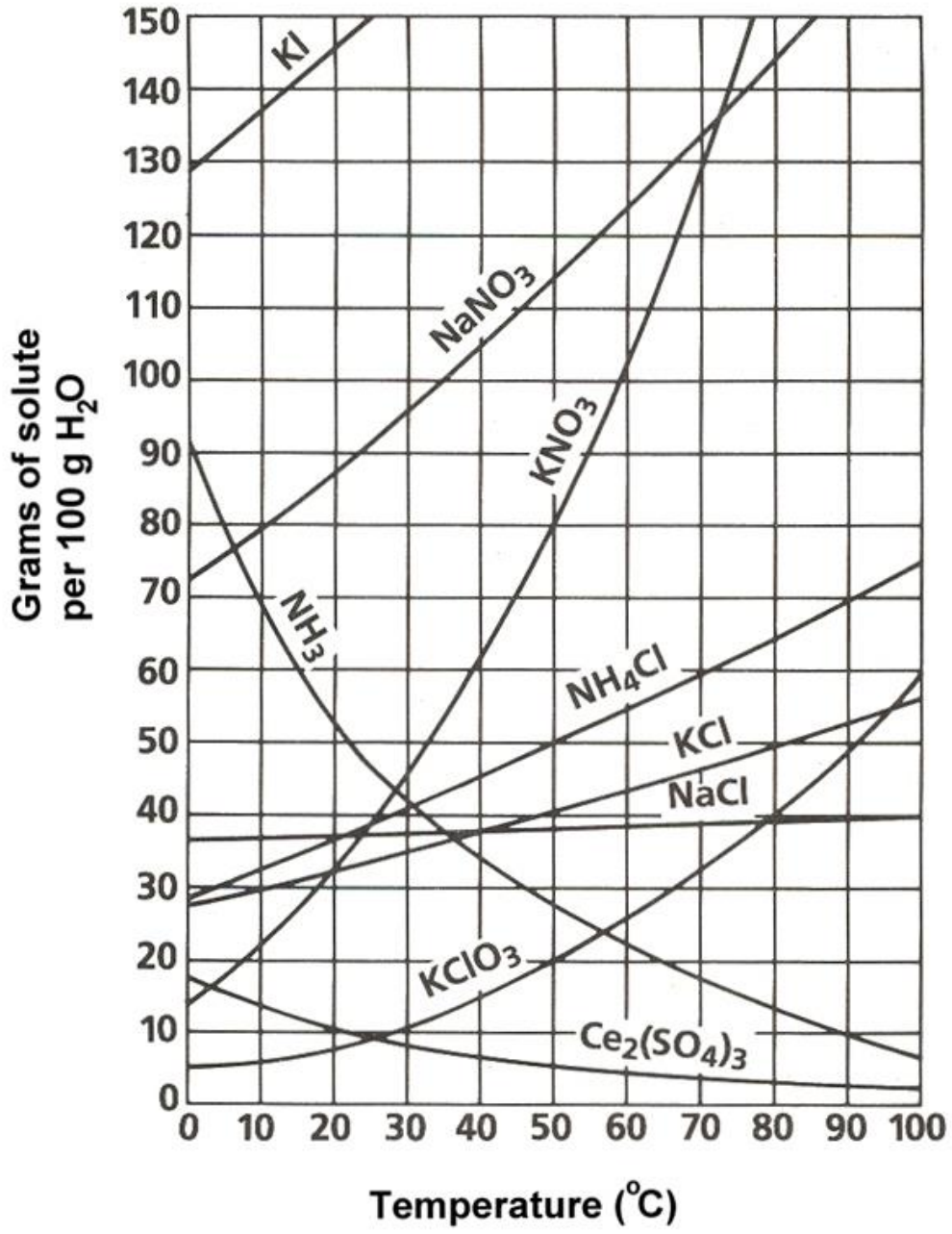
Question 2 (6 marks)

Use the graph to determine which of the salts potassium iodide, sodium nitrate or ammonium chloride, is the most soluble at 10°C in $molL^{-1}$.

Present your results and relevant working in a table.



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Most soluble salt in $molL^{-1}$…….

Question 3 (19 marks)

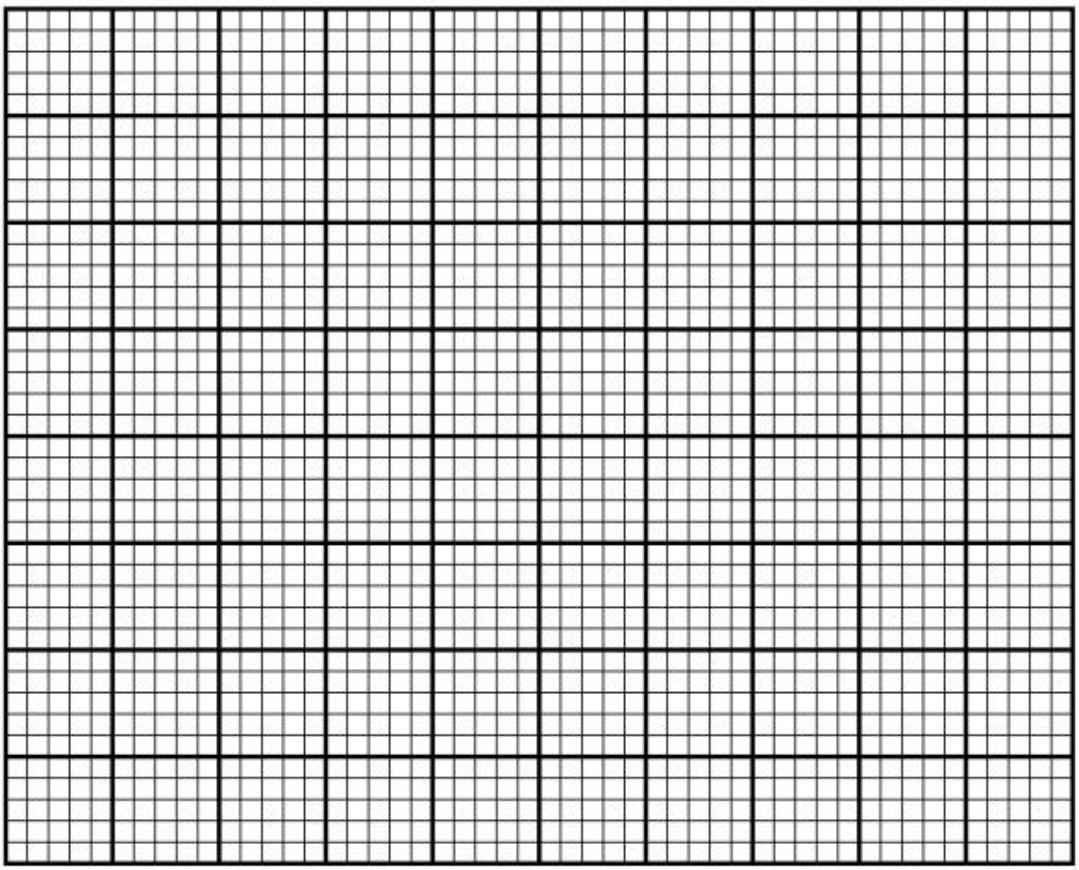
Reversible reactions in dynamic equilibrium proceed in the forward and backward directions at the same rate so that there is no net change.
Gases X_2 and Y_2 react in the following equilibrium.

$$X_2(g) + 3Y_2(g) \rightleftarrows 2XY_3(g)$$

Volumes of X_2 and Y_2 were reacted at 300°C. Over time, very small samples of the gas mixture were removed and analysed to determine the concentrations of the 3 gases.
These concentrations are recorded in the table below.

Time (hours)	*$[X_2]$ $molL^{-1}$*	*$[Y_2]$ $molL^{-1}$*	*$[XY_3]$ $molL^{-1}$*		*Time (hours)*	*$[X_2]$ $molL^{-1}$*	*$[Y_2]$ $molL^{-1}$*	*$[XY_3]$ $molL^{-1}$*
0	2.5	6.5	0.0		50	2.0	5.0	1.0
4	2.4	6.0	0.2		60	2.0	5.0	1.0
8	2.3	5.7	0.4		64	2.5	5.8	0.7
12	2.2	5.5	0.6		68	2.7	6.4	0.6
16	2.1	5.3	0.7		72	2.8	7.0	0.4
20	2.1	5.2	0.8		76	2.85	7.5	0.3
30	2.05	5.1	0.9		80	2.9	7.7	0.25
36	2.05	5.05	0.95		84	2.95	7.9	0.25
40	2.0	5.0	1.0		90	3.0	8.0	0.2
44	2.0	5.0	1.0		100	3.0	8.0	0.2

(a) Plot the concentrations of X_2, Y_2 and XY_3 on the same graph. Draw smooth curves to fit the points and label the curves. **6**



(b) At what time was equilibrium first established? Give a reason for your answer. **2**

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(c) Describe the rate of change of the concentration of Y_2 in the first 30 hours. **2**

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(d) At 60 hours the temperature of the system increased. In which direction did equilibrium shift at that time? Justify your choice. **1**

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(e) Determine whether the forward reaction is exothermic or endothermic and explain your answer. **2**

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The position of equilibrium can be quantified using the equilibrium constant expression.

For the reaction $aA + bB \rightleftarrows cC + dD$, the equilibrium constant expression is

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

(f) Write the equilibrium expression for the gaseous reaction between X_2 and Y_2. **1**

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(g) Calculate the equilibrium constant for the system at 50 hours. **2**

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(h) Calculate the equilibrium constant for the system at 90 hours. **1**

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(i) Outline how the value of the equilibrium constant can indicate the shift in the equilibrium position with a change in temperature. **2**

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Working Scientifically - Extra writing space

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Year 11 Working Scientifically Term 4 2018 Answers

Question 1 (15 marks)

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Aim

I tested 6 brands of detergent and found out how much water they contained. Then I compared their prices, so I could say which was the best value for money.

Equipment

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Method

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2. *Then I poured 20 mL of each detergent in a labelled evaporating basin.*
3. *I weighed each evaporating basin and put them in the drying oven.*
4. *3 days later I weighed them again and worked out how much water evaporated.*

Results

Detergent	*Starting weight of basin and detergent (g)*	*Final weight of basin and detergent (g)*	*Weight of water lost (g)*	*Price ($)*
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Magic Muscle	*146.7*	*130.8*	*15.9*	*6.34*

Conclusion

Golden Glow was the brand of detergent that lost the least water. It must have been the most concentrated. It was also the most expensive, so it was the best value for money.

(a) Suggest a more appropriate *aim* for this experiment. **1**

Sample answer

To determine which detergent is the most concentrated using gravimetric analysis.

Marking Criteria	*Marks*
• A realistic and quantifiable aim	1

(b) Rewrite the student's method using the appropriate language for a scientific report. **4**

Sample Answer

1. The evaporating basins were washed and dried.
2. 20 mL of each detergent was poured into separate labelled evaporating basins.
3. Each evaporating basin was weighed and all 6 were placed in the drying oven.
4. The basins were reweighed after 3 days and the change in mass calculated.

Marking Criteria	*Marks*
• 4 clear steps articulated in the past tense	4
• 3 clear steps articulated in the past tense	3
• 4 steps rewritten as directions	2
• Some rewriting of the method given	1

(c) Discuss the original method with respect to reliability and validity. **4**

Sample answer

The results are not reliable as each detergent was only tested once. Each detergent should have been tested at least 3 times to determine if results could be replicated and averages taken. The procedure is not valid. The independent variable was the detergent and the dependent variable the mass of water evaporated, however, other variables were not kept constant eg washing some basins and not others, suggesting that there may have been some extra water in the washed basins. Also, the volume of detergent in each bottle is not given so the comparison is not valid as eg the most expensive may have had the least volume in the bottle.

Marking Criteria	*Marks*
• Discusses the reliability and validity of the original method	4
• Discusses the reliability or validity of one and outlines the other	3
• Discusses the reliability or validity OR • Outlines the reliability and validity of the original method	2
• Shows some understanding of reliability or validity	1

(d) Describe three changes you would make to the method to improve this experiment. **6**

Sample answer

1. Rinse all the basins and dry them to avoid extra water ending up in some of the basins.
2. Repeat the experiment at least twice to improve the reliability of the results.
3. Compare price per mL of the detergents to determine value for money as well as water lost.

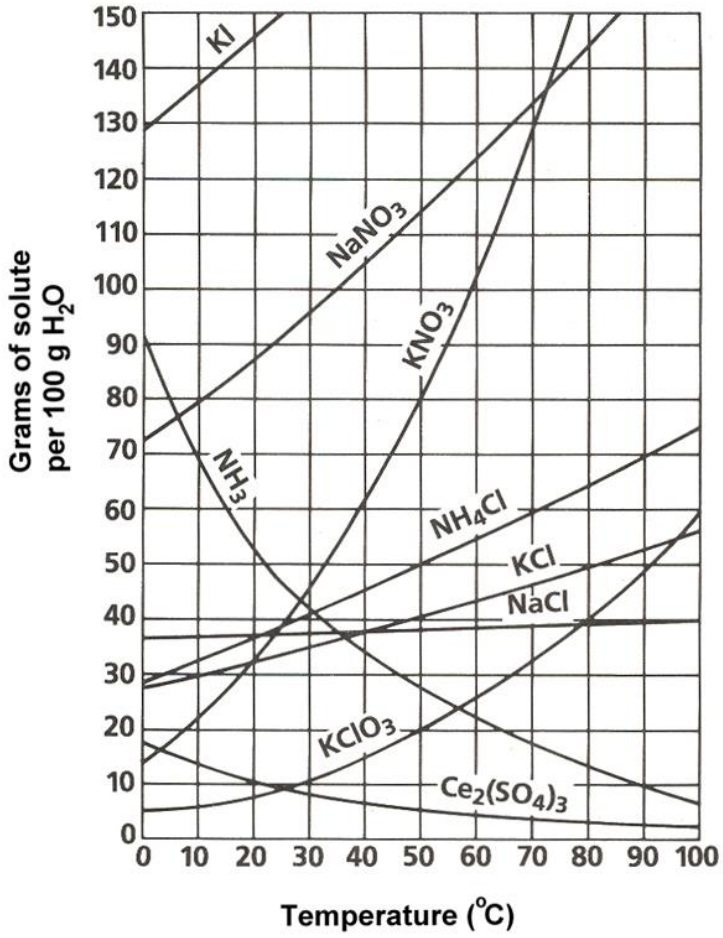
Marking Criteria	*Marks*
• Describes three changes and shows how they would improve the method.	6
• Describes two changes and shows how they would improve the method.	5

and • Outlines one change that will improve the method	
• Describes two changes and shows how they would improve the method. OR • Outlines 3 changes that will improve the method	4
• Describes one change and shows how it would improve the method. OR • Outlines two methods that will improve the method	3
• Outlines two changes	2
• Outlines one change	1

Question 2 (6 marks)

Use the graph to determine which of the salts potassium iodide, sodium nitrate or ammonium chloride, is the most soluble at 10°C in $molL^{-1}$.

Present your results and relevant working in a table.



NB The graph on your question sheet is larger and exactly $1cm^2$

Sample Answer

Salt	*solubility g/100g (+/- 0.5)*	*molar mass*	*mol/100g*	*molL^{-1}*
KI	137	39.1 +126.9 = 166	137/160 = 0.856	8.25
$NaNO_3$	79	22.99 + 14.01 +3(16) = 85	79/85 = 0.929	9.29
NH_4Cl	32.5	14.01 +4(1.008) + 35.45 = 53.49	33/53.99 = 0.611	6.02

Most soluble salt in molL^{-1} is sodium nitrate

Marking Criteria	*Marks*
• Appropriate table with units in the group headings • All relevant working shown for the three salts • Correctly identifies sodium nitrate as the most soluble salt in *molL^{-1}*	6
• Some table features • All relevant working shown for the three salts • Correctly identifies sodium nitrate as the most soluble salt in *molL^{-1} OR* • Appropriate table with units in the group headings • All relevant working shown for the three salts • Fails to identify sodium nitrate as the most soluble OR incorrect graph reading(s)	5
• Some table features • Some working shown for the three salts • Correctly identifies sodium nitrate as the most soluble salt in *molL^{-1}*	4
• Most relevant working shown	3
• Some working shown	2
• Some relevant information given	1

Question 3 (19 marks)

Reversible reactions in dynamic equilibrium proceed in the forward and backward directions at the same rate so that there is no net change.
Gases X_2 and Y_2 react in the following equilibrium.

$$X_2(g) + 3Y_2(g) \rightleftarrows 2XY_3(g)$$

Volumes of X_2 and Y_2 were reacted at 300^{o}C. Over time, very small samples of the gas mixture were removed and analysed to determine the concentrations of the 3 gases.
These concentrations are recorded in the table below.

Time (hours)	*[X_2] $molL^{-1}$*	*[Y_2] $molL^{-1}$*	*[XY_3] $molL^{-1}$*	*Time (hours)*	*[X_2] $molL^{-1}$*	*[Y_2] $molL^{-1}$*	*[XY_3] $molL^{-1}$*
0	2.5	6.5	0.0	50	2.0	5.0	1.0
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20	2.1	5.2	0.8	76	2.85	7.5	0.3
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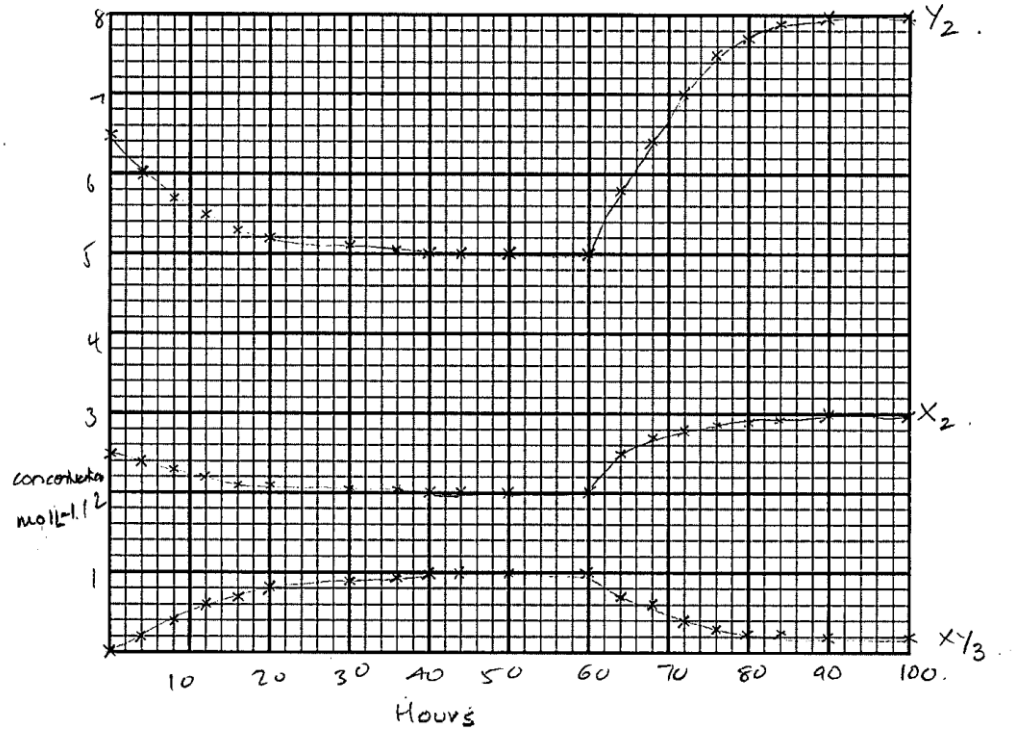
36	2.05	5.05	0.95	84	2.95	7.9	0.25
40	2.0	5.0	1.0	90	3.0	8.0	0.2
44	2.0	5.0	1.0	100	3.0	8.0	0.2

(a) Plot the concentrations of X_2, Y_2 and XY_3 on the same graph. Draw smooth curves to fit the points and label the curves. **6**



Marking Criteria	*Marks*
• Labelled axes • Sensible scale • Labelled curves • All plots correct for all 3 gases	6
• Labelled axes • Sensible scale • Labelled curves • Most plots correct for all 3 gases	5
• Most features of the graph correct • Most plots correct for all 3 gases	4
• Some features of the graph correct • Most plots correct (>3 incorrect)	3
• Some relevant features	2
• Some relevant graphing	1

(b) At what time was equilibrium first established? Give a reason for your answer. **2**

Sample answer

Equilibrium was first established between 36 and 40 hours when the concentrations of the three gases became constant with time.

Marking Criteria	*Marks*
• Correctly identifies 40 hours and gives a reason	2
• Correctly identifies 40 hours	1

(c) Describe the rate of change of the concentration of Y_2 in the first 30 hours. **2**

Sample answer

The concentration of Y_2 decreases quickly for the first 20 hours and then the rate of decrease slows from 20 to 30 hours.

Marking Criteria	*Marks*
• Describes the decrease in the concentration and the changing rate over time.	2
• Outlines the changes to Y_2	1

(d) At 60 hours the temperature of the system increased. In which direction did equilibrium shift at this time? Justify your choice. **1**

Sample answer

The equilibrium shifted left as the concentrations of the reactants increased.

Marking Criteria	*Marks*
• Justifies the shift to the left.	1

(e) Determine whether the forward reaction is exothermic or endothermic and explain your answer. **2**

Sample answer

As an increase in temperature favours the reaction that uses heat ie the endothermic reaction and more reactants are being formed, the reverse reaction is endothermic, so the forward reaction is exothermic.

Marking Criteria	*Marks*
• Identifies the forward reaction as exothermic with an explanation	2
• Gives an explanation but fails to identify the forward reaction as exothermic	1

The position of equilibrium can be quantified using the equilibrium constant expression.

For the reaction $aA + bB \rightleftarrows cC + dD$, the equilibrium constant expression is

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

(f) Write the equilibrium expression for the gaseous reaction between X_2 and Y_2. **1**

Sample answer

$$K_{eq} = \frac{[XY_3]^2}{[X_2][Y_2]^3}$$

Marking Criteria	*Marks*
• Correct equilibrium expression	1

(g) Calculate the equilibrium constant for the system at 50 hours. **2**

Sample answer

$$K_{eq} = \frac{[1.0]^2}{[2.0][5.0]^3}$$

$$= 4.0 \times 10^{-3}$$

Marking Criteria	*Marks*
• Correct calculation with 2 sig figs	2
• Correct calculation	1

(h) Calculate the equilibrium constant for the system at 90 hours. **1**

Sample answer

$$K_{eq} = \frac{[0.20]^2}{[3.0][8.0]^3}$$

$$= 2.6 \times 10^{-5}$$

Marking Criteria	*Marks*
• Correct calculation	1

(i) Outline how the value of the equilibrium constant can indicate the shift in the equilibrium position with a change in temperature. **2**

Sample answer

The equilibrium constant is smaller at the higher temperature indicating that there have been more reactants formed and therefore equilibrium has shifted to the left.

Marking Criteria	*Marks*
• Compares the two equilibrium constants and shows how the difference can indicate the shift in equilibrium	2
• Compares the two equilibrium constants OR • Shows how the difference can indicate the shift in equilibrium.	1