Eton College King's Scholarship Examination 2010

SCIENCE (SECTION 2 - DATA ANALYSIS)   (30 minutes)

Candidate Number:_____

Write your candidate number, not your name, in the space provided above.

This paper describes some data collected from experiments.

Read the information and answer the questions only in the spaces provided.

In questions involving calculations, all your working must be shown.

The graphs should be plotted on the graph paper provided. Make sure your candidate number, not your name, is clearly written on the graph paper that you hand in.

[Note to examiners: graph paper is required]

For examiners' use only.

Total [40]	

LST

1. A student carried out an experiment to investigate the solubility of two different solids at varying temperatures. The table below displays the results. These values show the maximum amount of solid that can be dissolved at a given temperature.

Temperature (°C)	Solubility of solid (g/100g of water)	
	Sodium chloride	Potassium chlorate
0	33.0	3.5
20	33.5	7.5
40	34.0	14.0
60	34.5	24.0
80	35.0	37.5

(a) Plot the results for the two different solids on the graph paper provided. Plot the controlled variable on the horizontal axis.

[5]

(b) At which temperature are the solubilities of sodium chloride and potassium chlorate the same?

_____ [1]

(c) If a saturated solution of potassium chlorate was made in 100g of water at 75°C what mass of dissolved solid would it contain?

_____ [1]

(d) If that solution in (c) was cooled to 25°C what mass of potassium chlorate would form as crystals?

_____ [1]

(e) What is the maximum amount of sodium chloride that could be dissolved in 1 kg of water at 50°C?

_____

_____ [2]

[Turn over]

LST

(f)   If 20g of each solid is added to one beaker containing 100g of water at 80°C and the solution is then cooled to 40°C crystals are observed. Which solid would you expect to crystallise and what mass of crystals would be formed? Also explain what assumption you have made in reaching your answer.

_____

_____

_____

_____ [3]

(g)   Is it still valid to discuss the solubility of a substance in water at temperatures just below 0°C?

_____

_____

_____ [2]

2.   The strength of acids and bases is measured on the pH scale. The following table includes pH values for different acids and bases.

Substance	pH value
ammonia	10
soda water	5
sodium hydroxide	14
lemon juice	3
sulphuric acid	1

(a)   Arrange these data in a suitable graph or chart on the graph paper provided.   [4]

[Turn over]

LST

Indicators are used to determine the different pH values of acids and bases by changing colour at a particular pH value. The following is a table of some indicators. The pH value in the table below is the value at which the indicator changes colour, from the colour at a lower pH to the different colour at a higher pH.

Indicator	Colour below	pH	Colour above
Bromophenol Blue	Yellow	4	Blue
Phenolphthalein	Colourless	9	Pink
Methyl Orange	Red	4	Yellow
Thymol Blue	Yellow	8	Blue

(b) Using the table above along with your suitable graph or chart, answer the following questions:

(i) What will the colour of thymol blue be in pure water?

_____ [1]

(ii) Which substance from your graph or chart will turn bromophenol blue, blue and thymol blue, yellow?

_____ [1]

Universal indicator is a mixture of many different indicators. It can therefore produce a range of different colours at different pH values.

(iii) An indicator was made by mixing together methyl orange and thymol blue. What colour changes would you see if sodium hydroxide solution was added slowly to a solution of sulphuric acid containing this indicator?

_____

_____

_____ [3]

(iv) At what pH values would the indicator make the changes in colour you have identified in part (iii)?

_____ [1]

[Turn over]

LST

A bottle of lemon juice contains citric acid. When lemon juice is reacted with sodium hydroxide solution a neutralisation reaction takes place. A scientist decided to test how much citric acid was in lemon juice by measuring the amount of sodium hydroxide (NaOH) needed to neutralise the lemon juice. He also reacted the same sodium hydroxide with a pure solution of citric acid and achieved the following results.

	Lemon juice	Citric Acid solution
Volume used (cm^3)	40	10
Volume of NaOH added (cm^3)	30	10

(c)   The citric acid solution tested had a concentration of 5g of citric acid in $100cm^3$ of solution.

(i) How many grams of citric acid are found in $40cm^3$ of lemon juice?

_____

_____

_____ [3]

(ii) A label on the lemon juice bottle said that $100cm^3$ of lemon juice contained 4.0g of citric acid. According to your results is that value correct, too little, or too much? Make sure to show your working.

_____

_____

_____ [2]

This citric acid solution reacts with an excess of magnesium ribbon to produce hydrogen gas. In an experiment $10cm^3$ of this citric acid produced $50cm^3$ of hydrogen gas when reacted with an excess of magnesium.

(iii) What volume of lemon juice would be required to produce $300cm^3$ of hydrogen gas when reacted with an excess of magnesium?

_____

_____

_____ [3]

LST

A group of students carried out the reaction between this citric acid and excess magnesium ribbon three times. Their results are shown in the following table.

Student	Volume of citric acid (cm^3)	Volume of hydrogen gas produced (cm^3)		
A	20	103	98	101
B	20	120	97	84
C	30	151	153	149
D	50	245	253	251

(iv) Which student produced the least reliable results? How can you tell?

_____

_____

_____ [2]

(v) Draw a diagram of the apparatus a student might use to carry out this experiment.

[3]

(vi) Student D argues with student A that his results are more accurate. Explain why student D is correct.

_____

_____

_____ [2]

(End of Paper)

LST