

<i>School</i>	<i>Candidate's Name (PLEASE PRINT)</i>
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WINCHESTER
COLLEGE

Election

2023

Science

CHEMISTRY

THEORY SECTION

Time allowed: 25 minutes

Write all your answers in the spaces on this question paper

You are recommended to spend 5 minutes on the multiple-choice questions (questions 1-6)

and then 5 minutes per question for questions 7, 8 and 9

MAXIMUM MARK = 25

Multiple Choice Questions

Do not spend more than 5 minutes on these multiple-choice questions

In each of the following six questions indicate the appropriate letter by writing it, legibly, in the space next to the answer. [1 each]

- 1 Select from the options below the technique which is best for separating pure water from a solution of copper(II) sulphate in water.
 - A crystallisation
 - B distillation
 - C chromatography
 - D filtration

- 2 A kitchen accident creates a mixture of crushed glass, sugar and water. The mixture is filtered. Select the option which correctly lists the component(s) found in the filtrate.
 - A glass
 - B sugar
 - C water
 - D sugar and water
 - E glass and water
 - F glass, sugar and water

- 3 Select the statement below which is **incorrect**.
- A carbon dioxide gas dissolves in water to give an alkaline solution
 - B when acids react with metal carbonates, the carbonate is behaving as a base
 - C universal indicator solution is blue at pH 9
 - D a “roaring flame” is the term used to describe a Bunsen burner giving out a blue flame
- 4 The rusting of iron was investigated using a pack of identical iron nails. Which of the following scenarios gave the fastest rate of rusting.
- A an iron nail was placed in a test tube together with some silica gel
 - B an iron nail was painted (the paint allowed to dry) and then placed in a test tube before being submerged in water
 - C reactive magnesium metal was wrapped around the top half of an iron nail which was then placed in a test tube before being submerged in water
 - D an iron nail was placed in a test tube and submerged in salt water
 - E an iron nail in a test tube was submerged in water that had just been boiled

- 5 Copper(II) carbonate powder is added to sulfuric acid in a beaker. Select the option below which gives the correct observations.
- A the green powder dissolves to give a colourless solution, the temperature of the solution rises, and lots of bubbles of gas are produced
 - B there is no visible change
 - C the grey powder dissolves to give a milky suspension
 - D the green powder becomes coated in a brown solid, the blue colour of the solution fades and the temperature of the solution rises
 - E the green powder dissolves, the solution turns blue in colour, the temperature of the solution rises, and lots of bubbles of gas are produced
 - F the green powder dissolves and the solution turns blue in colour

6 Select the option below which lists only correct chemical formulae.

- | | | | | |
|---|---|---------------------------------------|------------------------------|----------------------------|
| A | copper(II) sulfate Cu_2SO_4 | sodium chloride NaCl | iron Fe | lead Le |
| B | copper(II) sulfate CuSO_4 | sodium hydroxide SoOH | magnesium Mg | oxygen O_2 |
| C | copper(II) sulfate CuSO_4 | hydrochloric acid HCl | methane CH_4 | water H_2O |
| D | calcium carbonate CaCO_3 | sulfuric acid H_2SO_4 | carbon dioxide CO_2 | methane CH_3 |

[Total: 6]

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Please turn over for next question

Thermochemistry Question

- 7 Two students investigated separately the energetics of the reaction between solution A, a solution of potassium hydroxide, and solution B, a solution of nitric acid.

Solutions A and B were of equal concentration – that is to say equal number of reagent particles per unit volume. In this reaction each particle of potassium hydroxide reacts with one particle of nitric acid to make one particle of sodium nitrate.

Both students mixed samples of solutions A and B in identical polystyrene cups and used thermometers with markings every 0.1 °C.

Student 1 added 200 cm³ of solution A to 200 cm³ of solution B. The initial temperature of both solutions was 17.0 °C. The maximum final temperature of the mixture was 23.5 °C.

Student 2 added 50 cm³ of solution A to 100 cm³ of solution B. The temperature of both solutions was initially 17.5 °C.

The heat change, in kJ, created by the reaction, can be found using the equation

$$Q = V_w \times C_w \times \Delta T$$

Where: **Q** is the heat energy change that the reaction causes in the cup

V_w is the volume of water in cm³

C_w is the specific heat capacity of water, 4.18 J per cm³ per °C

ΔT is the temperature change in °C

(i) State and explain whether the reaction between potassium hydroxide and nitric acid is endothermic or exothermic.

.....
..... [1]

(ii) Calculate the heat transferred in Student 1's experiment.

.....
..... [1]

(iii) If Student 1's experiment creates 1.20×10^{23} particles of sodium nitrate, give the number of sodium nitrate particles formed in Student 2's experiment.

..... [1]

(iv) On the basis of Student 1's results, calculate the expected maximum temperature recorded by Student 2.

.....
.....
..... [2]

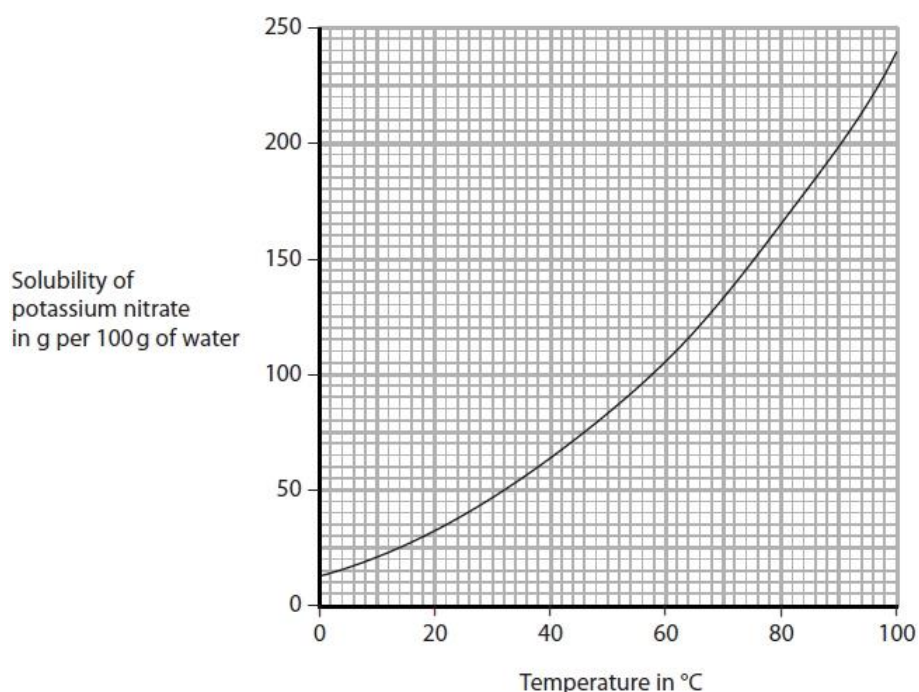
[Total: 5]

Salt Solubility Question

- 8 Sodium nitrate and copper(II) sulfate are example of a class of compounds called salts which can be formed by reacting acidic substances with basic substances. The salts thus formed are of variable solubility in water and their solubility depends upon temperature.

The graph below plots the solubility (mass of sold dissolved) of potassium nitrate as a function of temperature.

In this question the density of water can be taken as 1.00 g cm^{-3} .



- (a) Describe how the arrangement of particles changes when potassium nitrate dissolves in water.

.....
.....
.....

[1]

(b) From the graph, find the temperature that 100 cm³ of water would need to be heated to, for 50 g of potassium nitrate to fully dissolve.

..... [1]

(c) The temperature in the student's lab was 18 °C, what mass of solid potassium nitrate would precipitate out if a solution containing 50 g of potassium nitrate dissolved in 100 cm³ of water was allowed to cool to lab temperature.

.....
..... [2]

(d) If there are 50 g of water and the temperature is 25 °C, find, from the graph, the maximum mass of potassium nitrate that dissolved in the experiment.

..... [1]

[Total: 5]

Kitchen Chemistry Question

- 9 Chemical synthesis and the art of cooking have much in common: Chemists mix specific quantities of reactants to make specific products, whilst in the kitchen recipes are used to mix ingredients in the right ratios to make the correct quantities of food.

The 'cup' is used in American cooking as a standard measurement. This table shows approximate weights for a cup of different ingredients. Use the table to answer the questions below, and **don't forget** to show your working.

Ingredient	Ingredient	Mass of 1 cup/g
cocoa	C	75
oats	O	85
flour	Fl	128
brown sugar	Bs	150
butter	Bu	227
honey	Ho	300

An amateur baker likes to use American recipes for cooking. These recipes use 'cups' as a measure of ingredients. For example, 1 cup of flour weighs 128 g, which means they can convert American recipes into British weights.

- (a) For each of the quantities below, calculate the 'number of cups' equivalent to the stated mass.

256 g flour

75 g of brown sugar

[1]

The baker is practising for the BBC Bake Off competition. The baker is making a cake and is very flustered as four cakes are needed, one for each judge. The recipe is written out below:

2 cups of flour + 3 eggs + 1 cup of sugar + $\frac{1}{2}$ cup of butter \rightarrow 1 cake

(b) How many cups of flour should be used to make 4 cakes?

..... [1]

(c) If the baker's stock of ingredients includes 8 cups of flour, 15 eggs and 3 cups of sugar, and plenty of butter; how many whole cakes can be made?

.....
..... [1]

A teacher is making flapjacks – their favourite high-energy food – to give to pupils at break time. The recipe is written out below:

3 cups of oats + 1 cup honey + 1 cup of brown sugar + $\frac{1}{4}$ cup of butter \rightarrow 1 tray of flapjacks (20 flapjacks)

(d) The teacher finds that he has 280 g of oats and $\frac{1}{2}$ a cup of honey. Assuming he has plenty of brown sugar and butter, how many flapjacks can he make?

.....
.....
..... [3]

Please turn over for final question

(e) College Kitchen is preparing for a big tea party to mark the end of the final Election exam. The Head Chef collects 1135 g of butter and 2600 g of flour from the stores, ready to make cakes the following day. After he has gone home that evening, his keen assistant uses some of the butter to make 6 trays of flapjack using the recipe. The following day the Head Chef makes as many whole cakes (using the recipe) as he can with the remaining butter and flour. How many grams of flour goes unused? (**The table and recipes are repeated below.**)

.....

.....

.....

.....

[3]

[Total: 9]

Ingredient	Ingredient	Mass of 1 cup/g
cocoa	C	75
oats	O	85
flour	Fl	128
brown sugar	Bs	150
butter	Bu	227
honey	Ho	300

2 cups of flour + 3 eggs + 1 cup of sugar + ½ cup of butter → 1 cake

3 cups of oats + 1 cup honey + 1 cup of brown sugar + ¼ cup of butter → 1 tray of flapjacks (20 flapjacks)

End of this paper
[Total for paper: 25]