WESTMINSTER SCHOOL
THE CHALLENGE 2017
CHEMISTRY

Thursday 27 April 2017

Time allowed: 30 minutes

Instructions to candidates:

This paper has **four** questions.
You should answer **all** questions
There are 33 marks available.

The marks for individual questions and parts of questions are shown in square brackets []. **Calculators are allowed.** Any data needed will be given in the questions.

Please write in black or blue ink.
Write your answers in the spaces provided.

For examiner use only

Total Mark	

C1. The following multiple choice questions test a range of chemical principles. For each question, circle the letter corresponding to your chosen answer.

a) Some experiments are carried out on three elements (**X**, **Y** and **Z**). Use the information below to answer the questions that follow.

- **Y** does not react with the sulphate of **X**.
- **X** reacts with hydrochloric acid to produce a colourless gas, but reacts very slowly with water.
- **Z** reacts rapidly with water to produce a colourless gas.

(i) Which of the elements is the most reactive?

A X

B Y

C Z

D Not enough information available

[1]

(ii) How might you confirm the identity of the colourless gas produced from **Z** with water?

A introduce a glowing splint; splint relights

B introduce a lit splint; gas ignites

C introduce a lit splint; flame is extinguished

D Some other test

[1]

(iii) Which of the elements *could* be a non-metal?

A X

B Y

C Z

D None of them

[1]

b) When copper(II) carbonate is heated, the powder changes from green to….

A white

B blue

C yellow

D black

[1]

c) Which of the following is/are reactions that involve oxidation or reduction?

1. Sodium hydroxide + hydrochloric acid → sodium chloride + water
2. Copper(II) oxide + carbon → carbon dioxide + copper
3. Methane + oxygen → carbon dioxide + water

A Equation 2

B Equations 1 and 2

C Equations 2 and 3

D Equations 1, 2 and 3

[1]

[Total for C1: 5 marks]

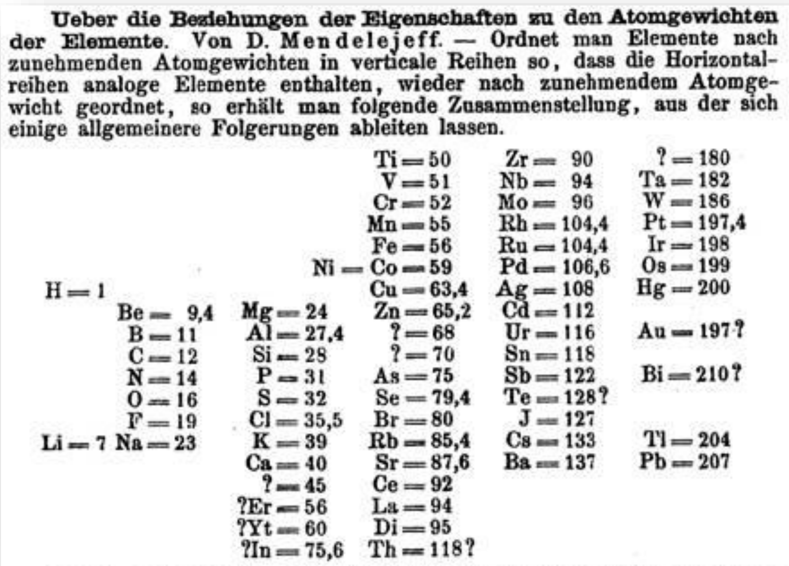
Question C2 begins on the next page

C2. This question is about the Periodic Table.

Dimitri Mendeleev's version of the Periodic Table celebrated its 148th anniversary earlier this year, but there are other versions which look very different to our modern interpretation.

This question does **not** require that you have an in-depth knowledge of any versions of the Periodic Table.

Consider the version below, which was first published in a German chemistry periodical (in 1869), and answer the questions that follow.



Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. Von D. Mendelejeff. — Ordnet man Elemente nach zunehmenden Atomgewichten in verticale Reihen so, dass die Horizontalreihen analoge Elemente enthalten, wieder nach zunehmendem Atomgewicht geordnet, so erhält man folgende Zusammenstellung, aus der sich einige allgemeinere Folgerungen ableiten lassen.

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 198
			Ni — Co = 59	Pd = 106,6	Os = 199
H = 1			Cu = 63,4	Ag = 108	Hg = 200
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,5	Br = 80	J = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,6	Th = 118?		

a) Define the term **atom**.

……

……

[1]

b) Suggest why some elements are represented by question marks in the table above (e.g. the element labelled as 180)?

……

……

[1]

c) From the elements in the table above, give the symbol of <u>**one**</u> element that might react with oxygen to form an acidic oxide.

……

[1]

d) Suggest what the numbers in the table represent.

………
[1]

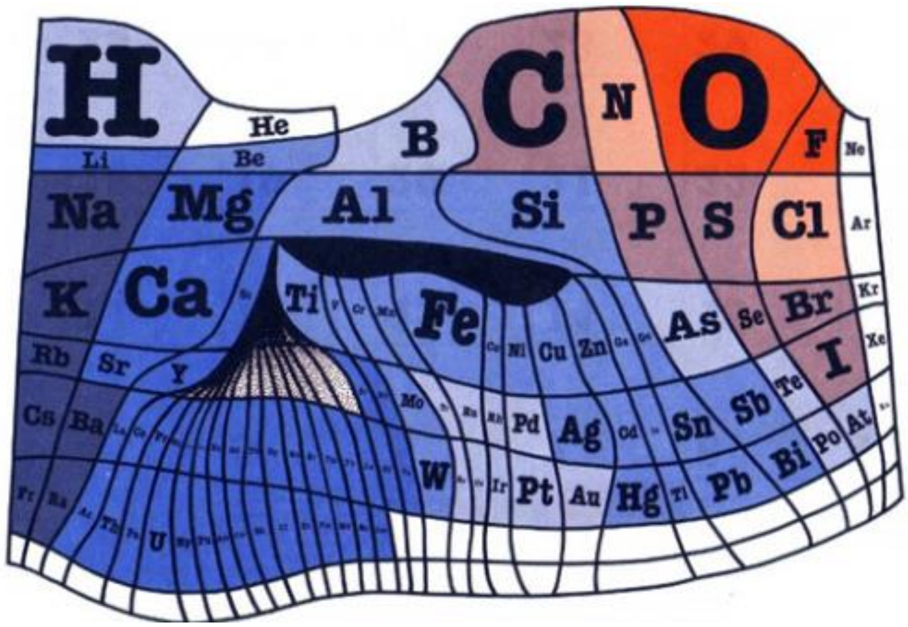
e) Elements in the same row all react in a similar way, forming compounds with similar formulae. Using your knowledge of common chemical compounds, suggest the formula for the combination of the following elements:

(i) Se with H ………………….

(ii) Sn with H ………………….

[2]

f) The following Periodic Table includes only the naturally occurring elements. Suggest what is represented by the relative size of each element.



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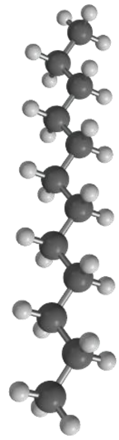
………
[1]

[Total for C2: 7 marks]

C3. This question is about cracking a hydrocarbon.



You do not need to have previously encountered any of the theory in order to tackle this question.

Hydrocarbons are molecules made up of only the elements carbon and hydrogen. Large hydrocarbons can be broken down into small ones *via* a process called cracking. This is an important industrial process since smaller hydrocarbons are much more useful as fuels.

Cracking dodecane (a hydrocarbon with 12 carbon atoms) gives two products, octane and butene.

dodecane → octane + butene

The table below summarises the boiling points of some common hydrocarbons. You may like to refer to this in your answers.

Hydrocarbon	No. of carbon atoms	Formula	Boiling point (°C)	State at room temperature
Butene	4	C_4H_8	– 6	
Dodecane	12	$C_{12}H_{26}$	216	Liquid
Ethane	2	C_2H_6	– 89	Gas
Methane	1	CH_4	– 161	Gas
Octane	8	C_8H_{18}	126	

a) Complete the table by writing the states of butene and octane at room temperature.

[2]

b) Predict the state of tridecane ($C_{13}H_{28}$) at room temperature.

………

[1]

c) By considering the formulae given in the table above, deduce the formulae of the following:

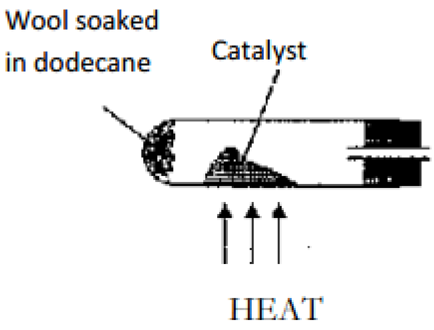
(i) Prop<u>ene</u> (contains 3 carbons)

(ii) Pent<u>ane</u> (contains 5 carbons)

[2]

d) Dodecane can be cracked in the laboratory with relatively simple apparatus. Complete the diagram below using the information provided.

- The hot gaseous products are passed *through* a boiling tube surrounded by ice.
- Some of the gases pass out of this boiling tube and are collected by displacement of water in a test tube.



[3]

e) What is the purpose of the boiling tube surrounded by ice?

………

………

[2]

f) If 10g of dodecane was heated and 6.8g of octane was collected. What is the total mass of gaseous products?

………

[1]

[Total for C3: 11 marks]

C4. This question is about the solubility of various compounds in water.

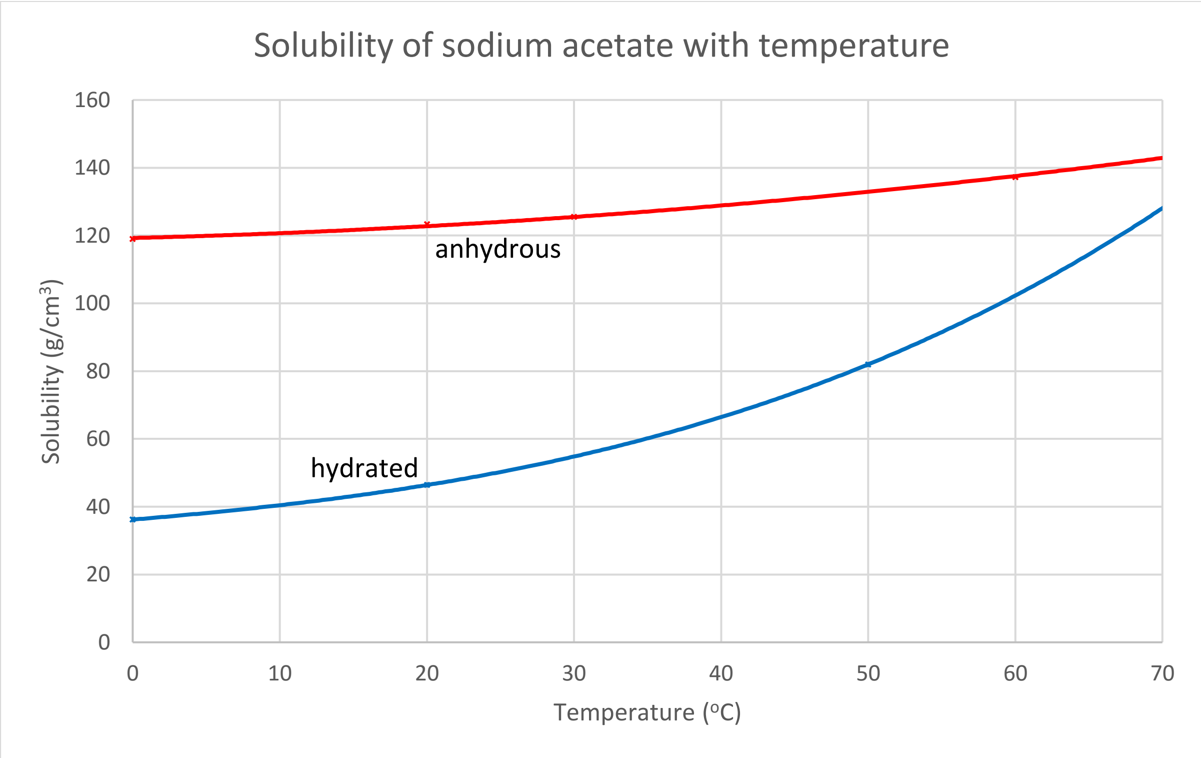
a) Define the term **solubility**.

………

………

[2]

The graph below shows the solubility of sodium acetate at various temperatures.



a) How might you convert hydrated sodium acetate into the anhydrous form?

………

[1]

b) Suggest why **hydrated** sodium acetate is less soluble than the anhydrous form.

………

………

[1]

Question C4 continues on the next page…

Two compounds, **A** and **B** are both soluble in water, but to varying degrees at different temperatures.

The solubility of compound **A** is given in the table below.

Temperature (°C)	**Solubility (g per 100g of water)**
0	128
20	144
40	162
60	176
100	192

c) Plot a graph of this data on the graph paper over the page, which **<u>already has data plotted for compound B</u>**. Draw a line of best fit through your points.

[2]

d) In an experiment, 66g of compound **A** and 20g of **B** were dissolved in 100g of water at 100°C. The solution was then cooled to 10°C.

(i) Identify which solid will crystallise out of solution at 10°C.

………

[1]

(ii) Calculate the mass of this solid that crystallises. Show on your graph how you have worked this out.

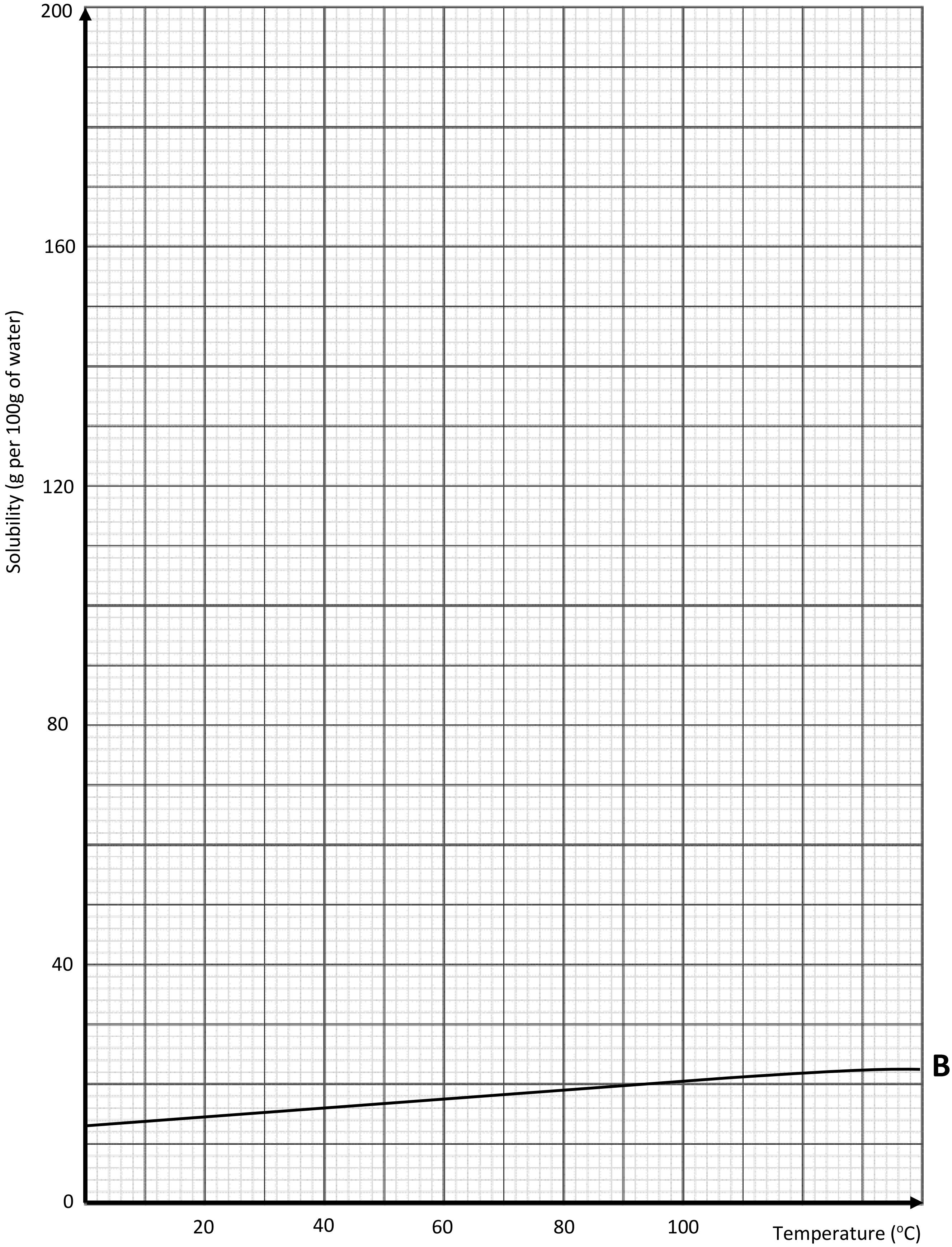
[2]

(iii) A student suggested that filtering this solution would leave behind a pure solution of the other compound. Comment on the validity of this statement.

………

………

[1]



[Total for C4: 10 marks]

END OF CHEMISTRY SECTION

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