WESTMINSTER SCHOOL
THE CHALLENGE 2019
CHEMISTRY

Thursday 2 May 2019
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	

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

a) Which of the following is always true for a pure substance?

A It always boils at 100°C

B It contains only one type of atom

C It has a sharp melting point

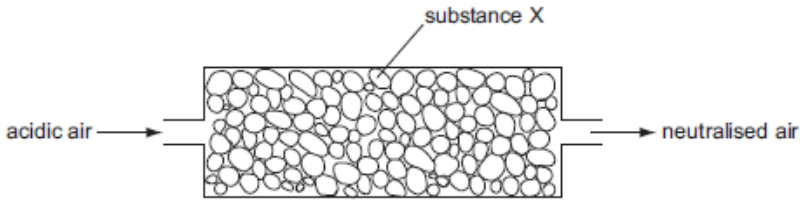
D It is a solid at room temperature

b) When pink cobalt chloride crystals are heated they form steam and a blue solid. When water is added to the blue solid, it turns pink and becomes hot.

Which terms describe the pink cobalt chloride crystals and the reactions?

	Pink cobalt chloride	**Reactions**
A	Aqueous	Irreversible
B	Anhydrous	Reversible
C	Hydrated	Irreversible
D	Hydrated	Reversible

c) Air containing an acidic impurity was neutralised by passing it through a column containing substance **Y**.



Which of the following might be substance **Y**?

A Calcium oxide

B Sand

C Sodium chloride

D Concentrated sulphuric acid

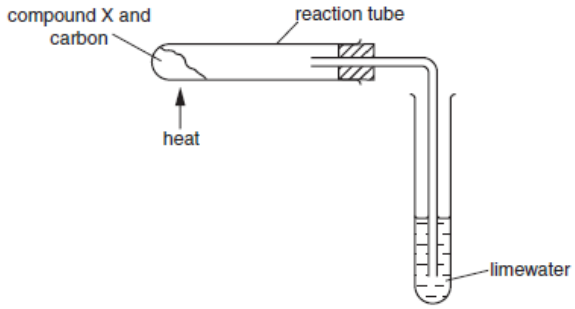
d) The table below shows the results of adding three metals, **P**, **Q** and **R** to dilute hydrochloric acid and to water.

Metal	Dilute hydrochloric acid	Water
P	Hydrogen produced	Hydrogen produced
Q	No reaction	No reaction
R	Hydrogen produced	No reaction

What is the correct order of reactivity of the metals?

	Most reactive → least reactive		
A	P	R	Q
B	P	Q	R
C	R	Q	P
D	R	P	Q

e) Compound **X** is heated with carbon using the apparatus shown.



A brown solid is formed in the reaction tube and the limewater turns cloudy. Identify compound X.

A Calcium oxide

B Copper oxide

C Magnesium oxide

D Sodium oxide

[Total for C1: 5 marks]

Question C2 begins on the next page

C2. This question is about the Periodic Table.

This year the Periodic Table celebrates its 150th birthday! Dmitri Mendeleev is credited with putting together the first version in 1869 when he was just 35 years old. You do not need to have studied the Periodic Table to answer the questions that follow.

The modern Periodic Table arranges the various elements according to their atomic properties.

a) Define the following terms:

(i) Atom

……

……

[1]

(ii) Molecule

……

……

[1]

(iii) Element

……

……

[1]

b) The vast majority of elements in the Periodic Table are metals, which can be recognised according to a chemical property of their oxides, or by a physical test.

(i) Suggest a physical test that may be used to identify a metal.

……

[1]

(ii) What is the chemical property that is shared by all metal oxides?

……

[1]

[Total for C2: 5 marks]

C3. This question is about fertilisers.

Ammonium nitrate is a compound commonly used in fertilisers to encourage healthy plant growth by dissolving in moisture in the soil. The table below shows the solubility of ammonium nitrate in water at various temperatures.

Temperature (ºC)	0	10	20	30	40	50	60	70
Solubility (g per 100g of water	28	36	44	52	60	70	82	96

a) Plot these results on the graph paper below. You should use an appropriate scale, label the axes and draw a line of best fit through the data.

Solubility of ammonium nitrate in water

[3]

b) Use your graph to answer the following questions:

(i) What is the solubility of ammonium nitrate at 28°C?

……

[1]

(ii) Calculate the amount of ammonium nitrate which would crystallise out of solution if 20g of saturated solution was cooled from 63°C to 28°C.

[2]

c) It is possible to recover the water from a solution of ammonium nitrate.

(i) Suggest what method might be used to remove (and retain) the water.

……

[1]

(ii) Give a chemical test that would show that the liquid produced was indeed water.

……

……

[2]

d) Ammonium nitrate can be made from the reaction between ammonium hydroxide (NH_4OH) and nitric acid (HNO_3), as in the equation below.

$$NH_4OH + HNO_3 \rightarrow NH_4NO_3 + H_2O$$

(i) What type of reaction is this?

……

[1]

(ii) A student added universal indicator solution to some nitric acid. They then added ammonium hydroxide (of the same concentration) drop by drop until the volume of solution had doubled. Suggest the colour of the indicator after the addition.

……

[1]

[Total for C3: 11 marks]

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C4. This question is about carbon dioxide.

The food and drink industries use a lot of carbon dioxide. During summer 2018, a global shortage led to supermarkets limiting frozen food deliveries and rationing beer. This is ironic considering the documented rise of atmospheric CO_2 levels.

a) What is the main adverse effect of a rise in atmospheric CO_2 levels?

……

……

[1]

b) The graph over the page shows how the temperature of two different gases (carbon dioxide and ammonia, NH_3) vary with pressure. Use this graph to help answer the following questions.

[1 atm = the pressure due to the atmosphere at the surface of the earth]

(i) State which of the two gases has the higher boiling point.

……

[1]

(ii) Calculate the drop in temperature when a pressurised sample of carbon dioxide drops from 10atm to 2atm.

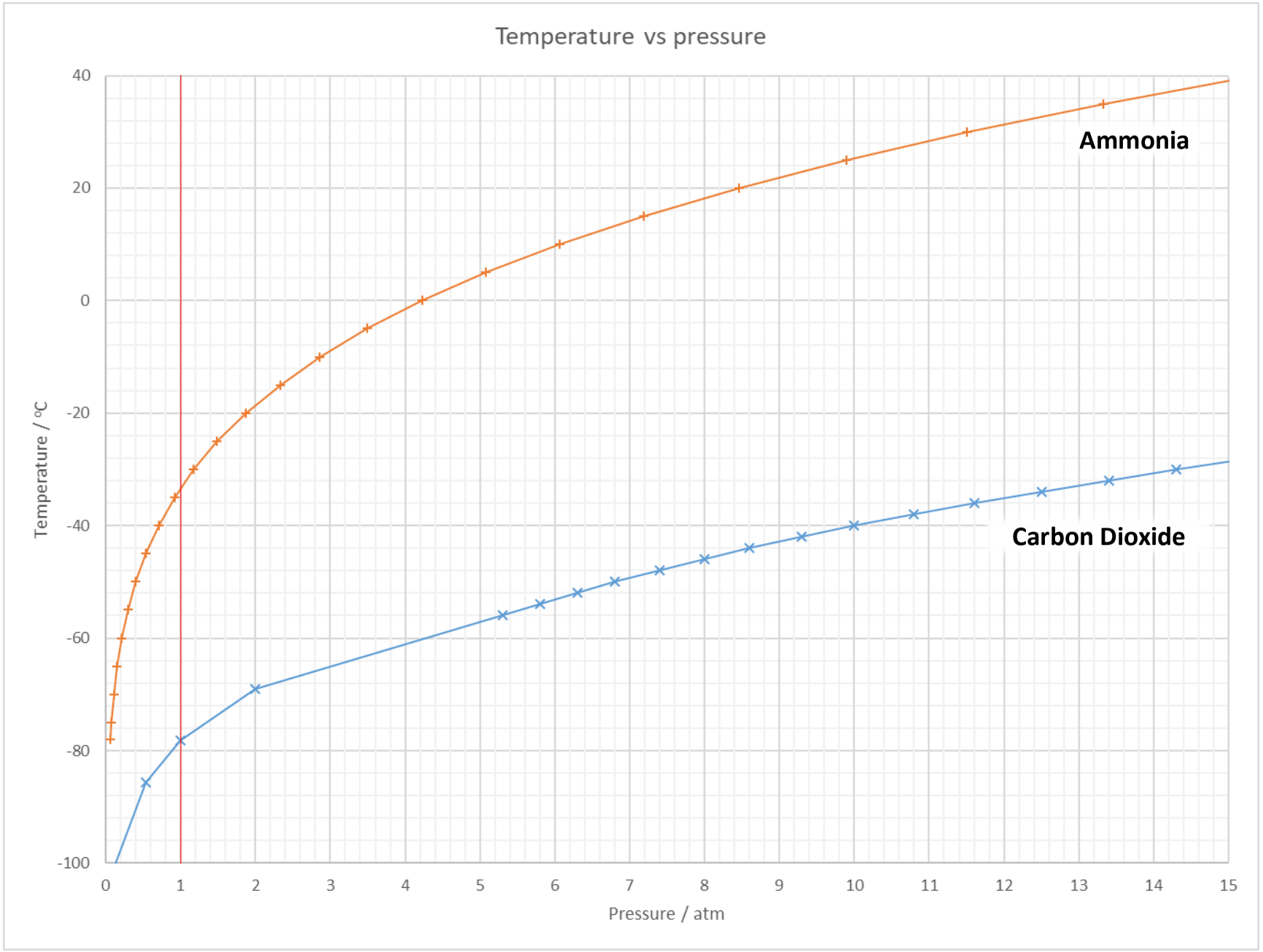
[2]

(iii) Calculate the difference in temperature between separate samples of carbon dioxide and ammonia, both kept at 10 atm.

[2]

(iv) Calculate the total pressure of an equal mixture of carbon dioxide and ammonia kept at –40°C.

[2]


Temperature vs pressure
Ammonia
Carbon Dioxide
Temperature / °C
Pressure / atm
40
20
0
-20
-40
-60
-80
-100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

c) There is a relationship called Henry's Law that relates the amount of pressure exerted on a gas to how much of it will dissolve in a solution. For carbon dioxide, the relationship may be expressed as follows:

"1.452g of carbon dioxide will be dissolved per 1 litre (1000cm^3) of solution, per atmosphere of pressure exerted on it."

(i) Given that a typical fizzy drink can (250cm^3) contains 1.089g of dissolved CO_2, calculate the pressure inside the can.

[2]

(ii) The maximum pressure that a fizzy drink can will withstand is 7 atm. Calculate the maximum mass of CO_2 that may be dissolved.

[2]

[Total for C4: 12 marks]

END OF CHEMISTRY SECTION