School	*Candidate's Name (PLEASE PRINT)*

WINCHESTER
COLLEGE

Election

Tuesday 24 April 2018

Science

CHEMISTRY

THEORY SECTION

Recommended time: 20 minutes

Write all your answers in the spaces on this question paper

A1 The production and release into the atmosphere of carbon dioxide by human activity has become a source of global concern. Two of the problems associated with increased levels of carbon dioxide in the atmosphere are climate change and ocean acidification.

(a) In the Carboniferous era, large amounts of carbon dioxide were removed from the atmosphere by plant life. Those plants that were buried before the carbon could re-join the carbon cycle locked their carbon underground.

(i) Name the process by which living things remove carbon dioxide from the atmosphere and convert it into other compounds.

…Photosynthesis (1)…… [1]

(ii) Explain how the carbon locked away in the Carboniferous era is now being released back into the atmosphere.

Burning fossil fuels / coal / oil / gas etc.

[1]

(b) Another human activity that releases carbon dioxide is the extraction of metals such as iron from their ores. Explain how the reduction of iron(III) oxide releases carbon dioxide into the atmosphere.

C / CO takes O from / reduces iron (ore) (1) ; to make CO_2 (1) OR

C / CO is oxidized (1) ; to CO_2 (1) OR CO_2 released by decomposing [2]

(1) ; limestone / calcium carbonate (1)

(c) Describe an experiment to show that carbon dioxide is an acidic gas.

Dissolve in water (1) ; indicator gives correct colour or other correct pH test (1) OR pass gas through solid or aqueous base (1) ; increase in mass / decrease in gas volume (1) [2]

(d) The manufacture of cement releases carbon dioxide from limestone according to the equation: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$.

(i) Name the type of chemical reaction exemplified by this process.

(Thermal) decomposition (1) [1]

(ii) Explain how this reaction could be used to show that calcium carbonate is not an element. Include any relevant measurements or observations that should be made.

Measure initial mass (1)

Measure final mass and it is lower (1)

Comparison of properties (1)

via correct test & observation (1) [to show that this is not simply evaporation] [4]

(e) Figure 1 shows the states of carbon dioxide at different combinations of temperature and pressure.

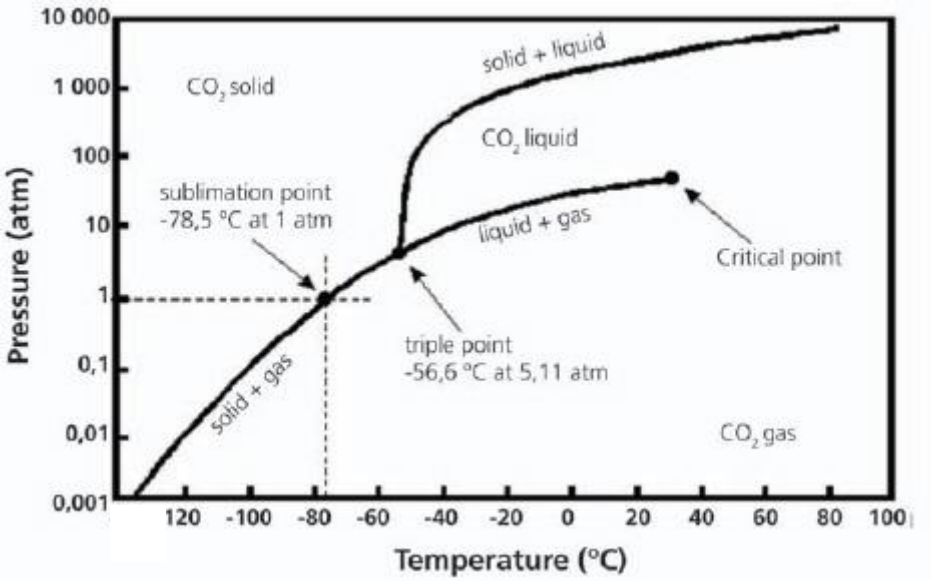


Figure 1: The phase diagram of carbon dioxide[1]

(i) Define *sublimation*.

Gas to solid (or vice versa) (1)

…… [1]

(ii) Give the minimum pressure at which carbon dioxide can exist in the liquid phase.

5.11 atm (1) [1]

(f) Carbon capture and storage technology (CCS) relies on the transport of carbon dioxide in the liquid phase.

(i) Give one **disadvantage** of transporting carbon dioxide as a liquid compared to transporting it as a gas.

High pressure / risk of explosion (1) [1]

(ii) Give one **advantage** of transporting carbon dioxide as a liquid compared to transporting it as a gas.

Lower volume / more per transporter / denser… (1) [1]

(g) Carbon dioxide may also be transported as a *supercritical fluid*. Supercritical fluids exist at temperatures and pressures greater than the *critical point* in the phase diagram. By considering what happens to a gas as it is compressed under increasing pressure and what happens to a liquid as it is heated, suggest why there ceases to be any distinction between liquid and gas phases beyond the critical point.

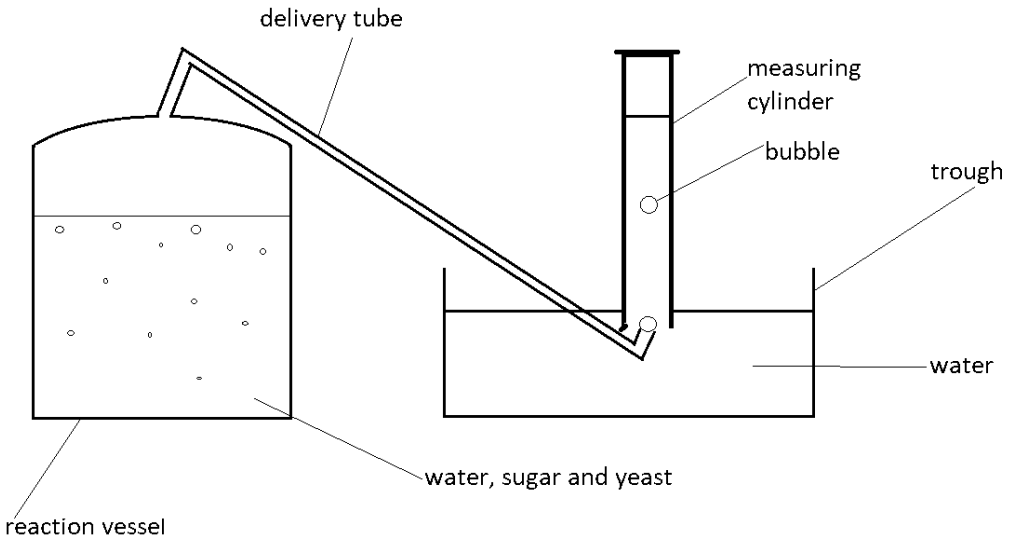
On compression, molecules get closer / density increases etc. (1)

On heating, molecules get further apart / density decreases /

molecules move more / escape attractive forces etc. (1)

Converge to point of same density / separation etc. (1) [3]

(h) Respiration contributes to the level of atmospheric carbon dioxide. A chemist investigating the volume of carbon dioxide released by the brewing industry set up the following experiment:



Under the conditions of the experiment, the amount of yeast does not increase. The data obtained were:

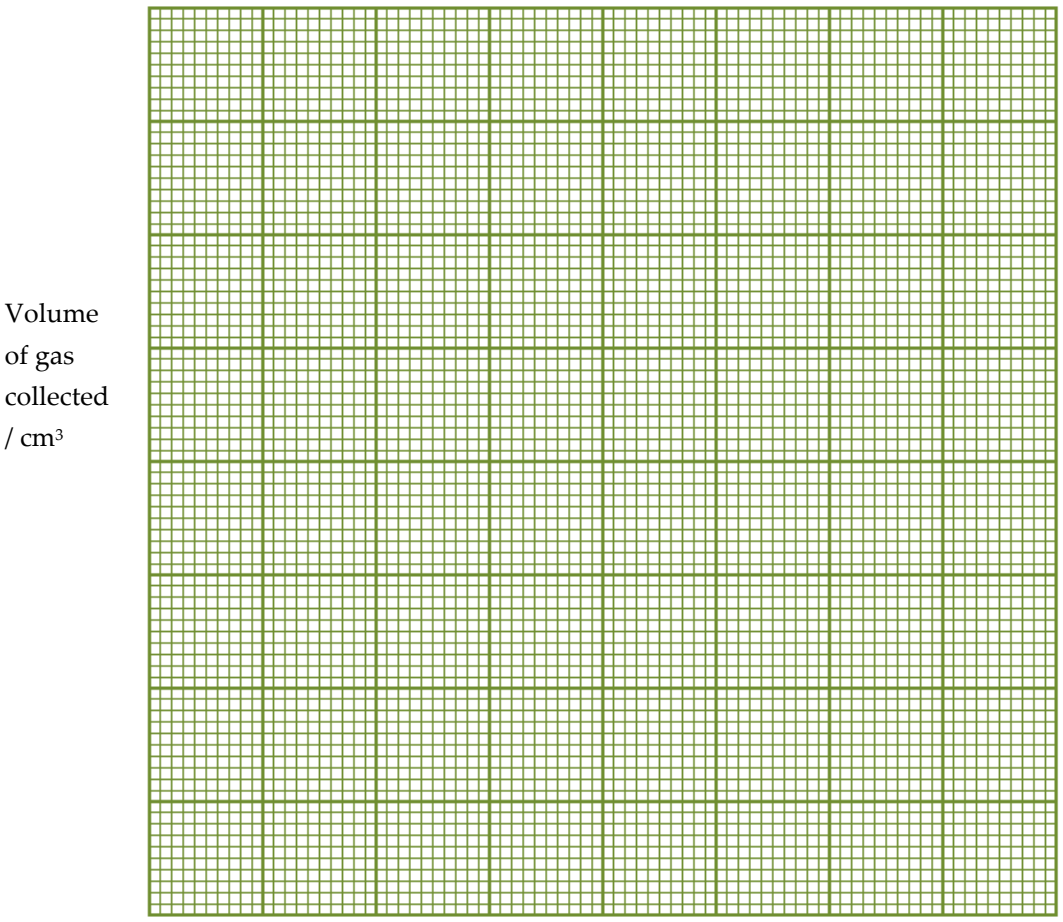
Time / h	0.0	1.0	2.0	3.0	4.0	5.0	6.0	8.0
Volume of gas collected / cm^3	10.0	11.5	13.0	14.5	19.2	24.0	28.5	37.9

(i) The temperature was kept constant. Give a reason why.

Fair test / controlled variable / gas volume comparable etc. (1) [1]

(ii) Plot the data on the graph paper opposite. [2]

Sensible scales (1) ; points correct (1)



(i) Draw two intersecting straight lines on the graph to fit the data. [1]

Instruction followed (1)

(ii) Suggest an explanation for the behaviour illustrated by the graph.

CO_2 dissolves at first (1)

Until saturated (1)

Then all further gas is released (1)

……

…… [3]

References:

1 https://hub.globalccsinstitute.com/publications/good-plant-design-and-operation-onshore-carbon-capture-installations-and-onshore-4#fig_001, retrieved January 2018.