

# CHEMISTRY

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

The number of marks is given in brackets [ ] at the end of each question, or part question.

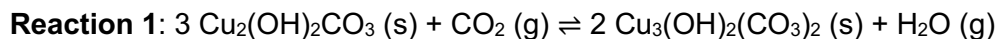
This document consists a total of **6** printed pages.

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- 1 Malachite and azurite are copper-containing minerals found in damp environments. The following table shows some data for malachite and azurite, as well as some other compounds.

Substance	Standard enthalpy of formation / kJ mol <sup>-1</sup>
Malachite, Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub> (s)	-1046.5
Azurite, Cu <sub>3</sub> (OH) <sub>2</sub> (CO <sub>3</sub> ) <sub>2</sub> (s)	-1629.5
H <sub>2</sub> O (g)	-248.12
CO <sub>2</sub> (g)	-393.51

Malachite and azurite undergo an equilibrium reaction below:



- (a) At standard conditions, a sample of malachite and azurite is in *dynamic equilibrium*.

(i) Define *dynamic equilibrium*. [1]

(ii) Define *Le Chatelier's principle*. [1]

- (iii) Explain changes to the composition of the sample of malachite and azurite when the following changes are applied separately:

(1) an increase in partial pressure of CO<sub>2</sub> (g); and

(2) an increase in the temperature such that malachite and azurite does not decompose. [4]

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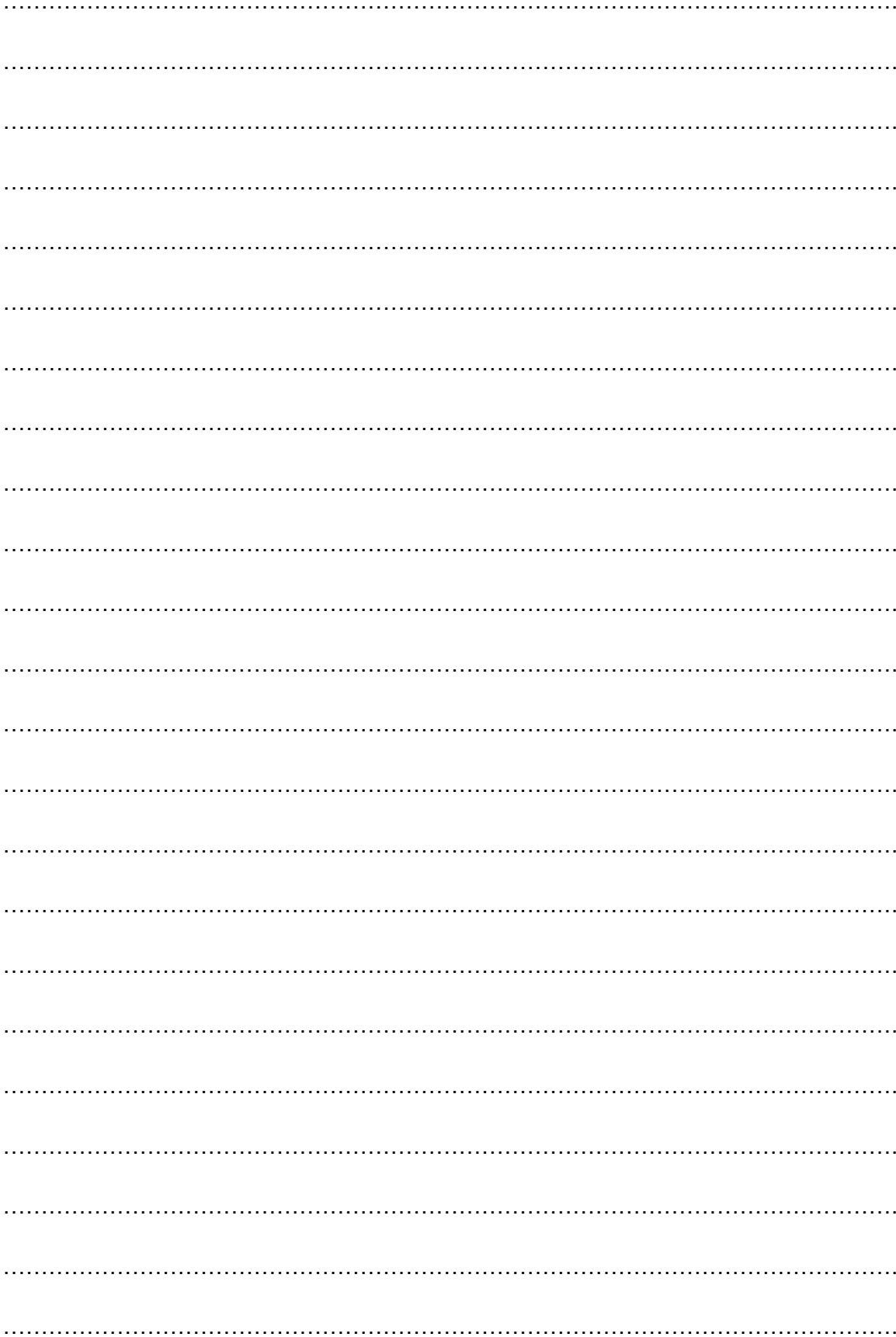
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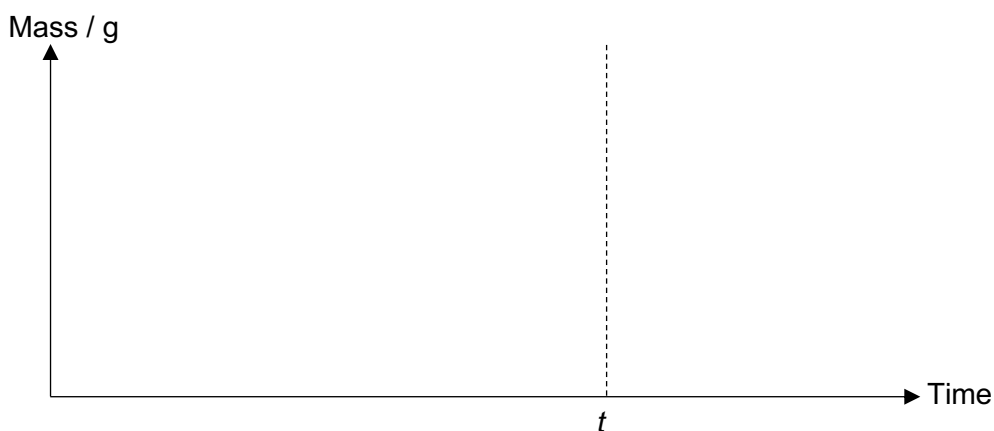
(c) In reality, a sample containing malachite and azurite at equilibrium will contain mostly malachite. The mass of azurite can be considered as negligible compared to that of malachite.

(i) A 100.00 g sample of pure azurite was left in an atmosphere that always contains the same percentage, by amount, of carbon dioxide and water vapour. Find the mass loss of the sample at equilibrium. [2]

(ii) Complete the graphs below in the scenario for (i). [2]

At time  $t$ , the system was at equilibrium.

1. Draw 2 lines, one for the mass of azurite, one for the mass of malachite.



2. Draw 2 lines, one for the rate of forward reaction, one for the rate of backward reaction of **Reaction 1**.



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[Total: 15]

Do practice

- Regular  $K_c$  problems
- Regular  $K_p$  problems (2 scenarios)
  - Where the total pressure remains constant
    - RICE table should be in moles
  - Where the total volume remains constant (i.e. pressure is allowed to change)
    - RICE table should be in partial pressure (but using moles is a perfectly acceptable approach)