Revision 8 Unit 3

1. Consider the image of the Downs cell shown below. This cell produces a reactive metal in commercial quantities when continuously supplied with an electrolyte composed of a mixture of NaCl and $CaCl_2$.

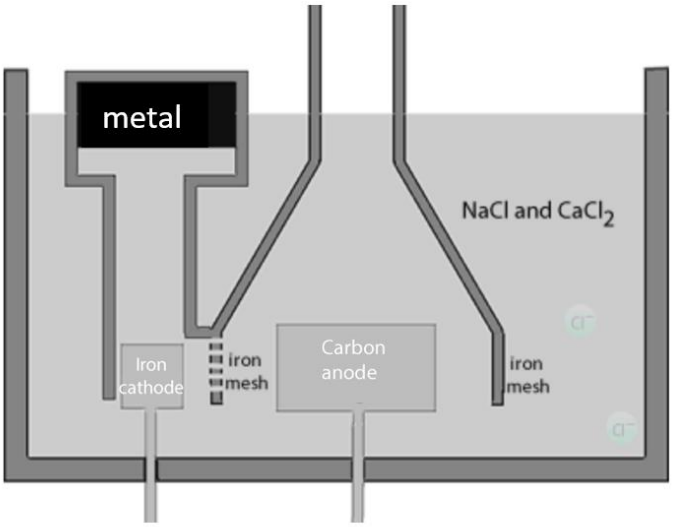

Diagram 1

a. What is the metal formed in this electrolytic cell? (*1 mark)*

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b. Justify your answer to question a. above. (*1 mark)*

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c. A current of 30,000 amps flows through the cell keeping the electrolyte in the molten state.
   i. Write the balanced reaction taking place at the anode. States included. (*2 marks*)

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   ii. Calculate the mol of electrons passing through the cell per hour. (*2 marks*)

   iii. Calculate the mass, in kg, of metal formed in one hour of operation. (*2 marks*)

d. What would be the consequences if the carbon anode was replaced with an iron anode? Justify your answer. (*2 marks)*

e. NaCl and $CaCl_2$ can be obtained from high concentration solutions in the form of brine. Can these solutions be used in the Downs cell? Explain (*2 marks)*

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3. Phosgene $COCl_2$ became important in the 19th century in dye manufacturing. It is also a critical industrial reagent in the synthesis of pharmaceuticals and other organic compounds. The reaction below shows the production of phosgene.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g) \quad \Delta H = \text{positive}$$

Carbon monoxide gas and chlorine gas are placed in a 4.00 litre reaction vessel and are allowed to react. The graph below shows the change in concentration of the reactants and product over time.

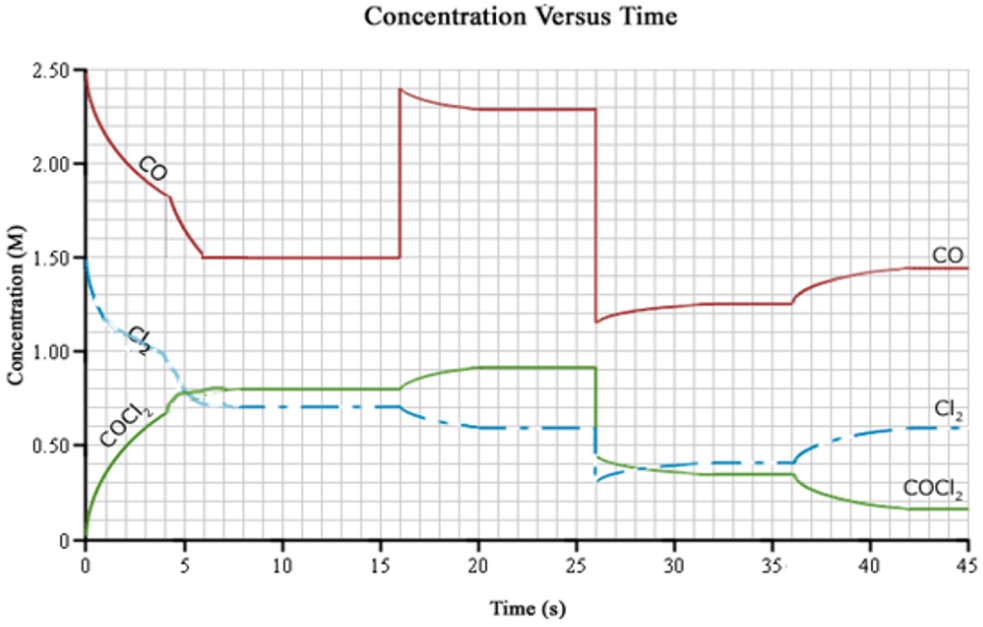

Diagram 2

a. Write the expression for the reaction quotient (Q) for the synthesis of phosgene gas ($COCL_2$) (*1 mark*)

b. Calculate the value of the reaction quotient at t = 10 s? Give the answer to the right number of significant figures and the appropriate units. (*2 marks*)

c. Give the most likely stress applied to the system at the following times and justify your answer. *(2+2+2=6 marks*)

i. T = 4 (use the [CO], red line, as a guide and assume constant temperature)

ii. T = 26

iii. T = 36

d. At t = 10 the system had an unknown substance added to it.

i. Using the response of the system, as seen on the concentration vs time graph, give one plausible suggestions as to what the substance may have been and justify your suggestion. (*1 mark*)

ii. Explain your answer to i. above. (*2 marks*)

4. Consider the concentration vs time graph, not drawn to scale, of a closed gas system, shown below.

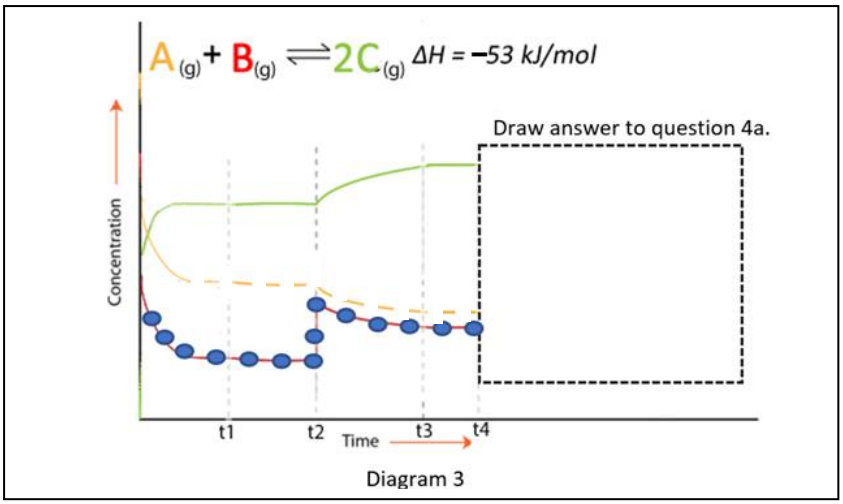

Diagram 3

a. At t4 the pressure of the reaction vessel is doubled by the injection of 10 mol of Helium gas. Clearly show, in the box provided, how the system responds after t4. (*1 mark)*

b. How does the value of the equilibrium constant(K) at t1 compare with the value of K at t3? Explain your reasoning. *(2 marks*)

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c. Three mol of gas A and three mol of gas B were placed in a 10.00 litre reaction chamber and allowed to reach equilibrium. When equilibrium was re-established the amount of C present was 0.160 mol.

i. Calculate the concentration of B, [B], present at equilibrium. (*2 marks)*

ii. Calculate the value, with appropriate units, of the equilibrium constant when equilibrium is established.
(*3 marks)*

iii. Calculate the pressure, in kPa, in the 10.0 litre reaction vessel at t1 if the temperature is kept constant at 100.0 ^{o}C. (*2 marks)*

iv. Soon after equilibrium is established, a stress was applied to the system at t2. Using this stress as an example, explain how:

- the reaction quotient(Q) changed. (*1 mark*)

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- the equilibrium constant (K) changed. (*1 mark*)

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d. During another experiment an unknown amount of substance C was placed in an empty three litre vessel at constant temperature. After some time had elapsed the reaction quotient stabilised at a value of 5.00 and the concentration of C was found to be 2.00 M.

i. Calculate the concentration of substance A present in the vessel, assuming no temperature change. (*2 marks*)

ii. Calculate the amount, in mol, of C originally placed in the vessel. (*1 mark)*

5. Consider the energy distribution graph shown in diagram 4.

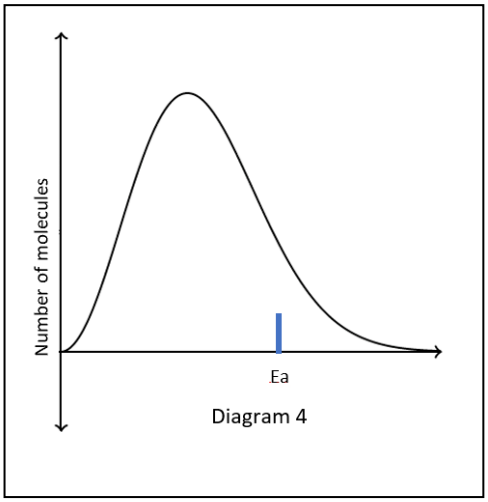

Diagram 4

a. Explain how a catalyst impacts the rate of a reaction. (*2 marks*)

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b. Consider the energy distribution graph below, diagram 5

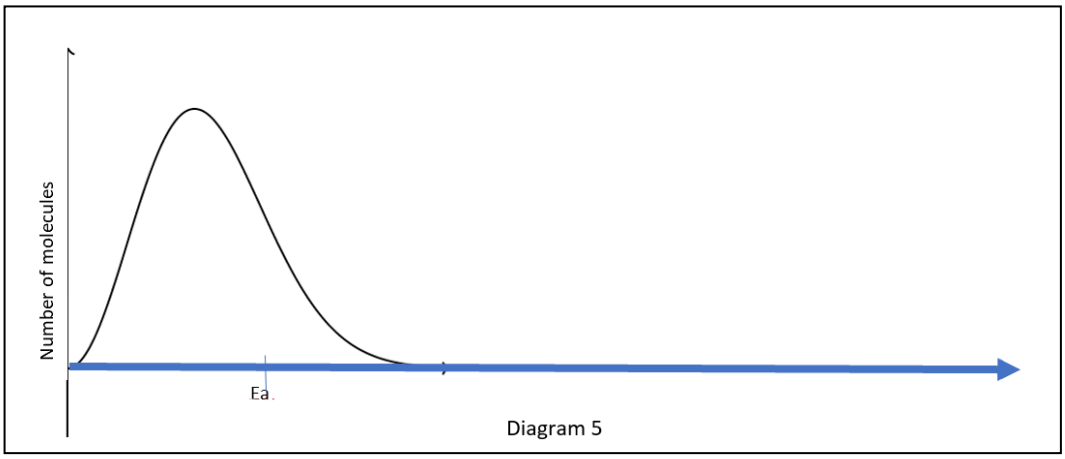

Diagram 5

i. Using the space provided in diagram 5, clearly draw a labelled diagram of how the graph may change when the temperature is increased. (*1 mark*)

ii. Explain how an increase in temperature impacts the rate of a reaction. (*2 marks*)

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6. The energy profile of the reaction below is shown on the right.

$$A(g) + B(g) \rightleftharpoons C(g)$$

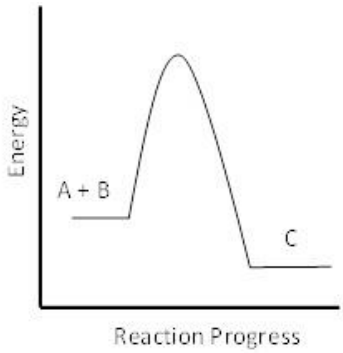

Diagram 6

a. What stress would increase the yield of the reaction? *(1 mark)*

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b. Explain how the stress given in question a, above, would increase the yield. (*1 mark*)

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c. Consider the following rate vs time graph, diagram 7, of the reaction $A(g) + B(g) \rightleftharpoons C(g)$.

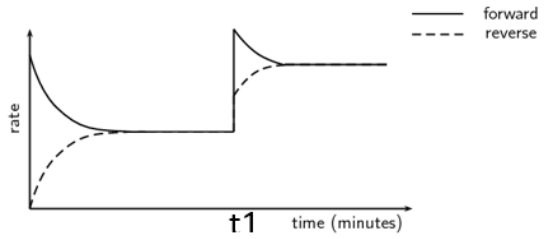

Diagram 7

i. State a likely stress placed on the system at t1. (*1 mark*)

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ii. Explain your answer to c. above. (*1 mark*)

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