2.17 Reversible Reactions and Equilibrium: 30-minute Pack

Total Marks

AQA 8464 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 When solid ammonium chloride is heated strongly at one end of a horizontal test tube, a white solid reforms further along the cooler part of the tube. This is a reversible reaction:
$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

(a) Name the type of change that happens to the ammonium chloride when it is heated. **(1)**

(b) State whether the forward reaction (heating the solid) is exothermic or endothermic. **(1)**

(c) Explain why a white solid reforms further along the cooler part of the tube. **(1)**

(Total for Question 1 is 3 marks)

2 Blue hydrated copper sulfate crystals, $CuSO_4.5H_2O$, can be heated to form white anhydrous copper sulfate powder, $CuSO_4$. This is a reversible reaction:
$CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(\ )$

(a) Complete the state symbol for the water in the equation above, given that it leaves the crystals as steam. **(1)**

(b) State the colour change seen when hydrated copper sulfate crystals are heated. **(1)**

(Total for Question 2 is 2 marks)

© Revision Library | revisionlibrary.co.uk

3 The dehydration of hydrated copper sulfate (heating it to drive off water) is endothermic and requires 120 kJ of energy to be transferred to the crystals per mole of water lost.

(a) State the energy change (exothermic or endothermic) for the reverse reaction, when water is added back to anhydrous copper sulfate, and give the amount of energy transferred. **(1)**

(b) Describe how the reaction profile (energy level diagram) for the reverse (hydration) reaction compares with the profile for the forward (dehydration) reaction. **(1)**

(c) Name the scientific law that explains why the size of the energy change must be the same in both directions. **(1)**

(Total for Question 3 is 3 marks)

© Revision Library | revisionlibrary.co.uk

4 A student investigates the reversible reaction between hydrated and anhydrous copper sulfate.

Method:

1. Weigh an empty boiling tube.
2. Add a sample of blue hydrated copper sulfate crystals ($CuSO_4.5H_2O$) and reweigh.
3. Heat the tube gently and continuously until no further colour change occurs, then allow it to cool and reweigh.
4. Add water dropwise to the cooled white solid.

$CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(g)$

(a) Suggest one piece of safety equipment the student should use during this practical, other than a lab coat. **(1)**

(b) Explain how the student knows that the dehydration reaction is complete. **(1)**

(c) Predict and explain what the student observes when water is added dropwise to the cooled white solid. **(2)**

(d) The student repeats the heating and weighing three times and records the following masses of water lost: 0.42 g, 0.40 g, 0.85 g. Identify the anomalous result and suggest one possible reason for it. **(2)**

(e) Calculate the mean mass of water lost, excluding the anomalous result. **(1)**

(f) Suggest one improvement to the method that would make the results more accurate. **(1)**

(g) Suggest why the student allows the tube to cool before adding water in step 4. **(1)**

© Revision Library | revisionlibrary.co.uk

(h) State one control variable that should be kept the same across all three repeats to ensure the results are comparable, and explain why. **(2)**

(i) Suggest one way the student could adapt the method to show how the mass of the tube changes over time as the crystals are heated, rather than measuring only the total change at the end. **(1)**

(Total for Question 4 is 12 marks)

---

5 Higher tier only. Reversible reactions can reach dynamic equilibrium if they take place in a closed system.

(a) State what is meant by a 'closed system'. **(1)**

(b) State two features of a reaction mixture that show it has reached dynamic equilibrium. **(2)**

(Total for Question 5 is 3 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 2.17 Reversible Reactions and Equilibrium: 30-minute Pack

Question 1

(a) thermal decomposition (thermal dissociation) oe **B1**

(a) Answer: Thermal decomposition (thermal dissociation).

(b) endothermic **B1**

(b) Answer: Endothermic.

(c) the ammonia and hydrogen chloride gases cool as they move along the tube and recombine (the reverse reaction occurs) to reform solid ammonium chloride oe **B1**

(c) Answer: The ammonia and hydrogen chloride gases cool as they move along the tube and recombine, reforming solid ammonium chloride.

Question 2

(a) (g) **B1**

(a) Answer: (g)

(b) changes from blue to white oe **B1**

(b) Answer: The crystals change colour from blue to white.

Question 3

(a) exothermic; 120 kJ (per mole of water) is released/transferred to the surroundings oe **B1**

(a) Answer: The reverse reaction is exothermic, releasing 120 kJ per mole of water added.

(b) the higher-energy forward products become the reverse reactants, and the lower-energy forward reactants become the reverse products; the energy levels keep the same heights oe **B1**

(b) Answer: The higher-energy products of the endothermic forward reaction become the reactants of the reverse reaction. The lower-energy forward reactants become the reverse products. The levels keep the same heights, so the reverse reaction releases 120 kJ per mole of water.

(c) the law of conservation of energy **B1**

(c) Answer: The law of conservation of energy.

Question 4

(a) eye protection (safety goggles); or a heatproof mat; or tongs/a tube holder to handle the hot tube oe **B1**

(a) Answer: Eye protection (safety goggles) should be worn, since a solid is being heated.

(b) there is no further change in colour (the solid is uniformly white), or no further loss in mass on reheating oe **B1**

(b) Answer: There is no further change in colour (the solid is uniformly white) and no further loss in mass on reheating.

(c) the solid turns blue again (as $CuSO_4.5H_2O$ reforms) **B1**

(c) the tube becomes warm/hot, because the reverse reaction (hydration) is exothermic oe **B1**

(c) Answer: The solid turns blue again as $CuSO_4.5H_2O$ reforms, and the tube becomes warm because the reverse (hydration) reaction is exothermic.

(d) 0.85 g is anomalous (it does not agree with/is much greater than the other two results) **B1**

(d) a plausible reason, e.g. the crystals were not fully dehydrated (heated to constant mass) in the other repeats, or a weighing/measurement error occurred in this repeat oe **B1**

(d) Answer: 0.85 g is anomalous, since it is far higher than the other two results. A weighing error could explain the high result.

(e) 0.41 g cao (allow ft from candidate's identification of the anomaly in part d) **B1**

(e) Answer: 0.41 g

(f) heat and reweigh repeatedly until the mass is constant (heat to constant mass) to ensure all the water has been driven off; or use a balance that measures to more decimal places oe **B1**

(f) Answer: Heat, cool and reweigh the tube repeatedly until the mass is constant (heating to constant mass), to make sure all the water of crystallisation has been driven off.

(g) to avoid the water boiling/spitting violently, or causing a burn from the hot glass/tube (safety) oe **B1**

(g) Answer: Adding water to the hot tube could cause the water to boil and spit violently, risking a burn, so the tube is allowed to cool first.

(h) a valid control variable, e.g. the mass of hydrated copper sulfate crystals used each time, or the heating time/method used each time oe **B1**

(h) so that any difference in the mass of water lost is caused only by genuine variation in the reaction, rather than by differences in the starting mass or heating conditions oe **B1**

(h) Answer: The mass of hydrated crystals used should be kept the same in each repeat, so that any difference in the mass of water lost is a genuine result and not simply caused by starting with a different mass of crystals.

(i) reweigh the tube and its contents at regular time intervals during heating (e.g. every minute) so that a mass-time graph can be plotted oe **B1**

(i) Answer: Reweigh the tube and its contents at regular time intervals during heating (for example, every minute), so the mass loss over time can be plotted on a graph.

© Revision Library | revisionlibrary.co.uk

Question 5

(a) a system in which no reactants or products (no matter) can enter or leave oe **B1**

(a) Answer: A closed system is one in which no reactants or products can enter or leave.

(b) the rate of the forward reaction equals the rate of the reverse reaction **B1**

(b) the concentrations of the reactants and the products remain constant (but are not necessarily equal to each other) oe **B1**

(b) Answer: At dynamic equilibrium, the forward and reverse reactions occur at the same rate, and the concentrations of reactants and products remain constant (though not necessarily equal to each other).

© Revision Library | revisionlibrary.co.uk