Mark scheme

Reversible reactions and equilibrium

Chemistry 0620 · Paper 4 (Extended)

Total marks

96

MARKS FOR EACH QUESTION

1	2	3	4	5	6	7	8	9	10	Total
6	7	7	9	10	10	11	12	12	12	**96**

Question 1 [6]

1(a)	large surface area / large area of contact / large surface; more (successful) collisions (between catalyst and gases or between reacting gases) **OR** more active sites **OR** faster reaction / increase rate / increase speed;	**2**	**I** activation energy Second mark must be comparative
1(b)	decrease temperature / temperature below 450 °C / quoted temperature below 450 °C; increase pressure / pressure above 200 atm / quoted pressure above 200 atm;	**2**	**I** comments about concentration **I** low temperature and high pressure. Both answers must be comparative **I** explanations
1(c)	decreased <u>temperature</u> would reduce rate / reaction slow**<u>er</u>** / too slow; increased <u>pressure</u> expensive / uneconomic / safety risks / leaks / explosions / yield **or** rate good enough at lower pressure / strong pipes needed / thick pipes needed / sturdy pipes needed / requires a lot of energy;	**2**	**A** takes long**<u>er</u>** **I** slow (unqualified) **I** answers that do not refer to decreased temperature and increased pressure e.g. it is too expensive unless this is linked with pressure

Question 2 [7]

2 **(a)** <u>rates</u> equal [1]
concentrations do not change / macroscopic properties remain constant [1]
accept amounts do not change

(b) endothermic [1]
cond favoured by high temperatures [1]

(c) **(i)** move to left [1]
cond bigger volume / more moles etc [1]
do not insist on “gas”

(ii) less yellow solid / more brown liquid [1]
accept yellow to brown / less solid more liquid / goes brown

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Question 3 [7]

3(a)	the **rate** of forward reaction equals the rate of the reverse reaction (1) **concentrations** of reactants and products are constant (1)	**2**
3(b)(i)	(increased pressure) nitrogen dioxide **particles** or **molecules** (forced) clos**er** together **OR** same number of nitrogen dioxide **particles** or **molecules** in a small**er** volume	**1**
3(b)(ii)	few**er** number of gas moles or molecules on left hand side or reactant side (of the equation) **ORA**	**1**
3(c)(i)	shifts to the right	**1**
3(c)(ii)	increase / faster (1) increase / faster (1)	**2**

Question 4 [9]

4 **(a)** **(i)** nitrogen 2+5 [1]

(ii) needs three electrons [1]
to complete energy level [1]

(b) **(i)** expensive metal / iron cheaper / better catalyst [1]

(ii) high pressure favours side with smaller volume / fewer moles [1]
this is right hand side / product / ammonia side [1]

(iii) recycled / sent over catalyst again [1]
accept used again

(iv) advantage high yield [1]
disadvantage slow reaction rate etc [1]

[Total: 9]

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Question 5 [10]

5(a)	**M1** The **rate** of forward reaction equals the rate of the reverse reaction(1) **M2 concentrations** of reactants and products are no longer changing(1)	**2**
5(b)(i)	same number of gas moles on both sides of the equilibrium **OR** same number of gas molecules on both sides of the equilibrium	**1**
5(b)(ii)	iodine **particles** or **molecules** (forced) closer together **OR** same number of iodine **particles** or **molecules** in a smaller volume	**1**
5(c)	endothermic	**1**
5(d)	**M1** –1 (1) **M2** zero (1)	**2**
5(e)(i)	copper	**1**
5(e)(ii)	no effect	**1**
5(e)(iii)	(activation energy is) low**er**	**1**

Question 6 [10]

6(a)	both colours referred to correctly as observations in both parts of the answer	**1**
	(if sulfuric acid is added to solution **Y**,) equilibrium moves to the right-hand side	**1**
	because the concentration of acid has increased	**1**
	(if sodium hydroxide is added to solution **Y**,) equilibrium moves to the left-hand side	**1**
	because sodium hydroxide reacts with / neutralises sulfuric acid	**1**
6(b)(i)	210 cm^3 **M1** expected volume of hydrogen = 300 cm^3 **M2** 70% of **M1**	**2**
6(b)(ii)	fewer moles / molecules / particles (of gas) on the left-hand side	**1**
6(b)(iii)	endothermic	**1**
6(b)(iv)	increases rate (of reaction)	**1**

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Question 7 [11]

7 **(a)** rate of forward reaction equals rate of back reaction [1]
concentrations do not change / macroscopic properties remain constant (with time) [1]
accept: amounts

(b) **(i)** increase [1]
reaction 2 [1]
Vr > Vp [1]

(ii) same [1]
reaction 1 [1]
Vr = Vp [1]

(iii) decrease [1]
reaction 3 [1]
Vp > Vr [1]
accept: moles of gas / molecules of gas as an alternative to volume

Question 8 [12]

8(a)(i)	Haber	**1**
8(a)(ii)	reversible / equilibrium	**1**
8(a)(iii)	450 °C (1) 200 atm (1)	**2**
8(a)(iv)	iron / Fe	**1**
8(a)(v)	equilibrium **shifts / moves** in forwards direction (1) fewer molecules / moles (gas) on RHS (1)	**2**
8(a)(vi)	particles have more energy (1) more collisions (between particles) occur per second / per unit time (1) a greater percentage / proportion / fraction of collisions (of particles) are successful / have energy above activation energy / have energy equal to activation energy (1)	**3**
8(b)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ $(NH_4)_2SO_4$ (1) correct equation (1)	**2**

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Question 9 [12]

9(a)	**M1** the rate of forward reaction equals (the rate of the) reverse reaction (1) **M2** the concentrations of reactants and products are no longer changing (1)	**2**
9(b)(i)	**M1** concentration decreases (1) **M2** position of equilibrium shifts to left **AND** fewer moles of gas on left hand side (1)	**2**
9(b)(ii)	**M1** concentration increases (1) **M2** position of equilibrium shifts to the right **AND** forward reaction is endothermic (1)	**2**
9(b)(iii)	**M1** no change (1) **M2** catalysts do not affect position of equilibrium (1)	**2**
9(c)(i)	carbon dioxide	**1**
9(c)(ii)	**M1** greenhouse gases absorb thermal energy (from the Earth) (1) **M2 and M3** one mark each for any two of: • energy (from the sun) absorbed by Earth's surface • Earth emits or reflects thermal energy • (greenhouse gases) reduces or stops thermal energy loss (into space) • increasing in amount of greenhouse gas results in a higher atmospheric temperature	**3**

Question 10 [12]

10(a)	$(4FeCuS\ 13O_2) \rightarrow 2Fe_2O_3 + 4CuO + 8SO_2$ Fe_2O_3 and CuO as a product (1) Equation fully correct (1)	**2**
10(b)(i)	**M1** rate of forward reaction = rate of reverse reaction (1) **M2** concentration of reactants and products are constant (1)	**2**
10(b)(ii)	**M1** 450 °C (1) **M2** 1-2 atm (1)	**2**
10(b)(iii)	vanadium(V) oxide	**1**
10(b)(iv)	increase rate of reaction	**1**
10(b)(v)	**M1** equilibrium shifts to left hand side (1) **M2** forward reaction is exothermic (1)	**2**
10(c)	$C_6H_{12}O_6 \rightarrow 6C + 6H_2O$ H_2O (1) balance (1)	**2**

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