Question 1

1(e)(vi)	⇌	1

Question 2

2(b)(i)	reversible reaction	1

Question 3

3(d)(i)	reversible reaction	1

Question 4

4(c)(i)	nothing can enter or leave	1
4(c)(ii)	**M1** the rate of forward reaction equals (the rate of the) reverse reaction **M2** concentrations of reactants and products are constant	2

4(c)(iii)	**M1** increases **M2** decreases **M3** decreases **M4** no effect	4

Question 5

5(a)	nitrogen: air (1) hydrogen: methane (1)	2
5(b)(i)	enthalpy change	1
5(b)(ii)	(the value of) ΔH is negative	1
5(b)(iii)	**M1** 450 (1) **M2** 20 000 (1) **M3** iron (1)	3
5(b)(iv)	one mark for each of |	| decreases decreases | decreases | no change	4
5(b)(v)	**M1** kinetic energy of particles increases (1) **M2** frequency of collisions between particles increases (1) **M3** higher percentage / proportion / fraction of collisions / particles have energy greater than / equal to activation energy (1) **or** more **of the** collisions / particles have energy greater than / equal to activation energy	3

Question 6

6(a)(i)	$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$	1
6(a)(ii)	iron(III) oxide	1
6(b)(i)	yield of SO_3 is less	1
6(b)(ii)	yield of SO_3 is less **OR** rate is less	1

Question 7

7(a)(i)	$S + O_2 \rightarrow SO_2$	1
7(a)(ii)	(temperature) 450 °C (1) (pressure) 1–2 atmosphere(s) (1) vanadium(V) oxide catalyst (1) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (1)	4
7(a)(iii)	$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$	1
7(a)(iv)	water	1

Question 8

8(a)	the **rate** of forward reaction equals the rate of the reverse reaction (1) **concentrations** of reactants and products are constant (1)	2
8(b)	reaction too slow (1) yield of ethanoic acid too low (1)	2
8(c)	increases (1) | decreases (1) | decreases (1)	3

8(d)	cobalt (1) transition element (1)	2

Question 9

9(a)	Haber (process)	1
9(b)	air	1
9(c)	reversible	1
9(d)	450 (1) 200 (1)	2
9(e)	Iron / Fe	1
9(f)	reduced temperature: **M1** (position of) equilibrium moves to right-hand side (1) **M2** reaction is exothermic (1) reduced pressure: **M3** (position of) equilibrium moves to left-hand side (1) **M4** more (gaseous) moles on left hand side (1)	4

9(g)	**M1** rate decreases **and** particles have less energy (1) **M2** less collisions (between particles) occur per second / per unit time (1) **M3** less of the particles/collisions have energy equal to or above the activation energy (1) **or** less of the particles / collisions have sufficient energy to react **or** a lower percentage / proportion / fraction of collisions (of particles) • are successful or • have energy equal to or above activation energy	3
9(h)	$(NH_4)_2SO_4$	1

Question 10

10(d)(i)	water(s) of crystallisation	**1**
10(d)(ii)	blue	**1**
10(d)(iii)	$CuSO_4 \cdot 5H_2O$ **M1** $CuSO_4$ (1) **M2** $\cdot 5H_2O$ (1)	**2**