Question number	Answer	Marks	Guidance
1 (a)	rate of forward reaction = rate of backward reaction concentrations of reactants and products remain constant	2	The concentrations remain constant. They are not the same.
1 (b)	fewer moles of gas on right-hand side therefore equilibrium moves to right side to oppose the change or reduce the applied pressure	2	
1 (c)	power or energy required to provide high pressure strong pressure vessel needed (to withstand high pressure)	2	This is to do with the energy needed for pumping.
1 (d)	*effect*: decreases *explanation*: reaction is exothermic system tries to lower *T or* remove constraint *or* oppose the change	3	If the effect is wrong you lose the explanation marks too.
1 (e)	to speed up reaction	1	You could say to give more molecules $E > E_a$
2 (a)	loss of electrons	1	
2 (b)	no change equal number of gaseous moles on either side therefore both sides affected equally increases equilibrium moves to lower the temperature or oppose the change forward reaction is endothermic	6	If the effect is wrong in either case you will lose the explanation marks too. It is worth working out the answer by always referring to Le Châtelier's principle.
3 (a)	the position of equilibrium moves to oppose any change	1	
3 (b)	(i) *effect on yield of hydrogen*: decreases *explanation*: pressure lowered or increase opposed by favouring fewer moles of gas (ii) *effect on yield of hydrogen*: increases *explanation*: equilibrium will move to the right	6	

	to remove the increase in steam *or* remove the increase in pressure		
3 (c)	*reason 1*: high temperature is expensive *reason 2*: cost of plant able to resist high temperature is too high	2	Don't just say expensive. You always need to qualify this.
4 (a)	mark labelled **X** on curve **A** where curve **C** joins **A**	1	
4 (b)	the position of equilibrium moves to oppose any change	1	
4 (c)	**B** more ammonia is produced fewer moles of gas on right (or 4 mol goes to 2 mol) equilibrium moves to oppose increase in pressure *or* oppose change	4	In (c) and (d) you must get the answers **B** and **C**, respectively, to be able to score the next marks.
4 (d)	**C** amount of ammonia unchanged reaction is faster	3	In (c) and (d) you must get the answers **B** and **C**, respectively, to be able to score the next marks.
5 (a) (i)	mol CH_4 = 0.75 mol H_2O = 1.5 mol H_2 = <u>1(.0)</u>	1 1 1	
5 (a) (ii)	0.15 mol dm^{-3}	1	<u>conseq = (mol CH_4)/5</u>
5 (b) (i)	$\frac{[CO_2][H_2]^4}{[CH_4][H_2O]^2}$ Not just numbers	1	do not penalise ( ) If wrong K_c no marks for calc but allow units conseq to their K_c
5 (b) (ii)	$(0.15 \times 0.25^4) / (0.10 \times 0.48^2)$ 0.025(4) $mol^2\ dm^{-6}$	1 1 1	No marks for calc if concs used wrongly or wrong values inserted allow 1 here for correct units from wrong K_c
5 (c)	increase 1 lower P	1 1	if wrong, no further marks in (c) not "greater volume" for M1 but allow "moves to form a

	eqm shifts to side with more moles (Le Châtelier)	1	greater volume" for M2
5 (d)	(forward reaction is) endothermic or backward reaction is exothermic eqm shifts in exothermic direction or to oppose reduction of or change in temp	1 1	 This mark must have reference to temp change or exothermic reaction