Question	Answer	Marks	Guidance
1 a	72 (1)	1	unit **not** needed **ignore** any unit given
b	C_4H_6 / H_6C_4 (1)	1	**not** if superscripts used for the numbers
c	C_2H_2 **and** C_6H_6 (1)	1	**both** needed if no answer on answer line **allow** other ways of indicating the correct answer e.g. circling, ticking or underlining
d	Mole ratio C : H is 0.1 : 0.4 (1) Empirical formula is CH_4 / H_4C(1)	2	**LOOK AT THE ANSWER FIRST IF CH_4 / H_4C AWARD 2 MARKS** **allow** moles of C = 0.1 and moles of hydrogen = 0.4 **allow** moles of C = 1.2/12 and moles of hydrogen = 0.4/1 **allow** C_1H_4 **allow** full marks despite any working out for correct empirical formula
	Total	**5**	

Question	Answer	Marks	Guidance
2 a	**[Level 3]** **Deduces how increasing temperature and pressure affects the percentage yield** **AND** **Explains how addition of carbon dioxide will shift the position of equilibrium** Quality of written communication does not impede communication of the science at this level (5 – 6 marks) **[Level 2]** **Deduces how changing temperature and pressure affects the percentage yield** **AND** **Describes how adding carbon dioxide shifts the position of equilibrium** Quality of written communication partly impedes communication of the science at this level (3 – 4 marks) **[Level 1]** **Deduces how changing temperature affects the percentage yield and how changing pressure affects the percentage yield** **OR** **Describes how adding carbon dioxide shifts the position of equilibrium** Quality of written communication impedes communication of the science at this level (1 – 2 marks) **[Level 0]** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to A.** **Indicative scientific points at level 3 must include:** • To minimise addition of carbon dioxide reaction uses up carbon dioxide i.e. shifts to the right **Relevant points at all levels could include explanations** • as temperature increases percentage yield decreases / as temperature increases position of equilibrium shifts to the left / ora • as pressure increases percentage yield increases / as pressure increases position of equilibrium shifts to the right / ora • Addition of carbon dioxide shifts position of equilibrium to the right / ora **Use the L1, L2, L3 annotations in scoris. Do not use ticks.**

Question	Answer	Marks	Guidance
b	**any two from:** can share ideas / have different views (1) can evaluate ideas / check results / can compare results (1) can collect more evidence (in a shorter time) / more productive / can do more approaches / can work faster / more ideas can be tested (1) can share cost of research (1)	2	**allow** small discoveries can be combined into a large one **allow** help to make new predictions **allow** results would be more reliable **ignore** results are more accurate
	Total	**8**	

Question			Answer	Marks	Guidance
3	(a)	(i)	increases / gets bigger / AW (1)	1	
		(ii)	decreases / gets less / AW (1)	1	
	(b)		idea of catalyst used to speed up the reaction or increase the rate of reaction (1) 70 atm used as is cheaper to generate than higher pressures (1) 300 ^{o}C is used to increase the rate of reaction but sacrifice percentage yield / it is a compromise or optimum temperature (1)	3	**allow** catalyst does not affect percentage yield (1) **allow** answer relating to the risks associated with high pressure (1)
	(c)		idea of **reduction** of wage bill / idea of **reduction** of number of workers (1)	1	**ignore** rule out human error **ignore** to make the process work faster **ignore** references to safety **ignore** it is a continuous process **not** no labour costs
			Total	**6**	

Question			Answer	Marks	Guidance
4	(a)		32 (g) of methanol makes 60 (g) of ethanoic acid / 10 moles of methanol is used / 32 x 10 = 320 (1) So 320 (g) makes 600 (g) of ethanoic acid (1)	2	**allow** two marks for the correct answer of 600g even if no working out
	(b)		atom economy = $\frac{60}{60+18}$ / $\frac{60}{46+32}$ / $\frac{60}{78}$ (1) **but** atom economy = $\frac{60}{60+18} \times 100$ / $\frac{60}{46+32} \times 100$ / $\frac{60}{78} \times 100$ (2)	2	**allow** atom economy formula in words for one mark i.e. atom economy = <u>total Mr of desired products</u> x 100 (1) total Mr of all products
	(c)		percentage yield = $\frac{9.5}{9.8}$ (1) **but** percentage yield = $\frac{9.5}{9.8} \times 100$ (2)	2	**allow** percentage yield formula in words for one mark e.g. percentage yield = <u>actual yield</u> x 100 predicted yield or percentage yield = <u>am</u> x 100 pm
	(d)	(i)	more sustainable / makes less or no **waste** products (1)	1	makes less waste is **not** sufficient **ignore** makes less products **ignore** it wastes less resources
		(ii)	less waste of reactants (1)	1	**allow** no need to recycle unreacted reactants **ignore** less waste / waste products **ignore** able to make more / more products made
			Total	**8**	

Question			Answer	Marks	Guidance
5	(a)		**any two from:** replaces essential elements (used by previous crop) / provides extra essential elements / provides **two** named essential elements (1) (more) nitrogen used to make plant protein (so increased growth) / nitrogen used to make amino acids (1) (more) phosphorus used to make ATP (1)	2	**ignore** reference to nitrates, ammonium and phosphates **ignore** reference to minerals and nutrients the essential elements are nitrogen, phosphorus **and** potassium
	(b)		20 / twenty (1)	1	
	(c)	(i)	potassium hydroxide (1)	1	**allow** KOH **allow** potassium carbonate / potassium hydrogencarbonate / K_2CO_3 / $KHCO_3$ **ignore** potassium oxide
		(ii)	hydrogen ions reacted with hydroxide ions (to make H_2O) (1)	1	**allow** $H^+ + OH^- \rightarrow H_2O$ **allow** H^+ react with OH^- **allow** H^+ counteracted by OH^- / H^+ balanced by OH^-
			Total	**5**	

Question			Answer	Marks	Guidance
6	(a)		$2SO_2 + O_2 \rightarrow 2SO_3$ formulae correct (1) balancing (1) balancing mark is conditional on correct formulae	2	**allow** = instead of → **not** and / & / instead of + **allow** any correct multiples, including fractions **allow** one mark for correct balanced equation with minor errors of case, subscript and superscript eg 2SO2 + O_2 → 2SO3
	(b)	(i)	(increasing the temperature) reduces the yield of sulfur trioxide (1)	1	
		(ii)	catalyst increases rate of reaction (1) a lower temperature would give a better yield but would slow the reaction (1) a higher pressure would increase the yield but a higher pressure would increase plant cost / higher pressure would increase the yield but increase energy cost / higher pressure increases the yield but increases the safety risks (1)	3	 **allow** ora must specify the actual cost involved **allow** ora
			Total	**6**	

Question			Answer	Marks	Guidance
7	(a)	(i)	ammonia is needed in large amounts / ammonia is needed in high demand / AW (1) drugs or medicines are made on a relatively small scale / easy to switch to making a different drug / drugs are needed in small amounts / AW (1)	2	**allow** ammonia needed all year round **allow** demand for drug may be seasonal **allow** a batch can be re-called if there is a problem
		(ii)	making drugs is more labour intensive / more specialised or qualified workers to make a drug / less automation is possible when making drugs / more research and testing in drug manufacture / raw materials for drug manufacture may be rare or expensive to extract from plants / legislative demands (1)	1	**allow** ora for fertiliser labour costs are high is **not** sufficient **more** workers is not sufficient **allow** idea of need to have careful testing (of batches) / idea need to have more quality control
	(b)	(	percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}}$ × 100 (1) **but** $\frac{6.0}{8.0}$ × 100 (2)	2	**allow** $\frac{\text{am}}{\text{pm}}$ × 100 (1) **or** $\frac{6.0}{8.0}$ = 0.75 (1) 0.75 x 100 (1) No mark for 75%
		(ii)	**any two from:** to reduce wasting **reactants** (1) to reduce costs / to make more money / to make more profit (1) saves wasting energy (1)	2	**ignore** reduces waste / reduces waste products / waste materials to make money is **not** sufficient / to make a profit is **not** sufficient / to save money is **not** sufficient
			Total	**7**	

Question			Answer	Marks	Guidance
8	(a)		nitrogen + hydrogen → ammonia (1)	1	**allow** N_2 + (3)H_2 → (2)NH_3 (1) balancing not required **allow** = or ⇌ instead of → **not** 'and' or '&' instead of '+' **not** '+ heat' or + catalyst' on LHS of equation
	(b)		⇌ (1)	1	**allow** ⇋ or ⇄ or ⇆ (1)
	(c)		30(%) (1)	1	**allow** any value between 29 and 30 (1)
	(d)	(i)	pressure = 600 (atmospheres) **and** temperature = 350(^{o}C) (1)	1	**both** required
		(ii)	idea that there is a need for high pressure or high temperature (1) idea of higher energy costs or equipment costs (1)	2	**allow** idea that reaction is too slow (1) so have to pay labour costs or energy costs for a longer time (1)
	(e)		3 / three (1)	1	
			Total	**7**	

Question			Answer	Marks	Guidance
9	(a)		$\frac{34}{267}$ x 100 (1)	1	**allow** $\frac{34}{(233+34)}$ x100 / $\frac{34}{(98+169)}$ x 100 the mark is for the working out and not the answer
	(b)		$\frac{18}{20} \times 100$ / $\frac{18}{20}$ (1) 90 (1)	2	**allow** $\frac{am}{pm} \times 100$ for one mark if answer incorrect **allow** full marks for 90(%) with no working out
	(c)		because the atom economy is low / lots of atoms are wasted in the reaction (1)	1	**allow** lots of waste made / produces waste products / produces barium sulfate which is not used **not** reference to percentage yield
			Total	**4**	