Question number	Answer	Notes	Marks
1 a i	(pressure) low		1
ii	fewer (gas) moles/molecules/particles on left OR fewer moles/molecules/particles of reactants OR forward reaction produces more moles/molecules/particles	Accept statement about numbers of moles / molecules, eg 3 on left and 5 on right Accept more (gas) moles/molecules/particles on right / more moles/molecules of products but not just more products Ignore references to favouring right hand side/forward direction /endothermic reaction /equilibrium shifting to right /Le Chatelier's principle /low pressure favours side with more moles Ignore references to rate / collisions If answer to (i) is high, no ECF in (ii) If no answer to (i), mark can be awarded in (ii)	1
b i	(temperature) high		1
ii	(forward) reaction is endothermic / has positive ΔH value / absorbs heat	Accept reverse reaction is exothermic / has negative ΔH value / gives out heat Ignore favours the endothermic reaction Ignore references to rate / collisions If answer to (i) is low, no ECF in (ii) If no answer to (i), mark can be awarded	1

c	ΔH (value)/enthalpy change is small / smaller / less (than for reactions 1 and 3) OR reaction not very exothermic / has lowest enthalpy change	Accept energy in place of enthalpy Accept clos<u>er</u> to zero Reject ΔH less negative / less exothermic / less heat given out Ignore references to temperature change / pressure Ignore less energy / not a lot of energy needed	1

Question number	Answer	Notes	Marks
1 d		Ignore references to yield / equilibrium / chances of collision in (i) d (ii)	
i	(rate) increases		1
ii		Mark M1 and M2 independently	2
	M1 particles closer together	Accept more particles in a given volume/space /particles have less space/room (to move in) Ignore area in place of volume/space Ignore references to just numbers of gas moles/molecules	
	M2 particles collide more frequently	Not just more (successful) collisions Accept more (successful) collisions per unit time / per second, etc 0/2 if references to particles moving faster/having greater energy If answer to (i) is decreases, no ECF in (ii) If no answer or ignored answer to (i), marks can be awarded	

Question number	Answer	Notes	Marks
1 e	Accept working by mass ratio OR moles routes Mass ratios: M1 M_r (CH_3OH) = 32 AND M_r (CH_3COOH) = 60 M2 m($_3$COOH) = $\frac{64 \times 60}{32}$ M3 120 (kg) OR Moles: M1 n($_3$OH) = 64 000 ÷ 32 = 2000 (mol) M2 n($_3$COOH) = 2000 (mol) M3 m(CH_3COOH) 0 × = 120 0 0 g / 1 0 (kg)	Award M1 for 32 and 60 seen anywhere, except as the result of incorrect calculations Mark M2 and M3 consequentially on M_r values Allow working in 'kilomoles' even if mol given as unit or no unit for intermediate answers, eg 64 ÷ 32 = 2 (kmol/mol) CQ on M1 CQ on M2 Correct final answer with or without working scores 3 marks Accept 120 000 g if unit shown	3
		Total 11 marks	

Question number	Answer	Accept	Reject	Marks
2 (a)	(produces) most heat/energy per gram / per unit mass	highest temperature rise per gram / per unit mass most energy for smallest number of grams / mass	per amount	1
(b)	(produces) most heat/energy per mole/per molecule /per amount	highest temperature rise per mole / per molecule most energy for smallest number of moles / molecules / amount		1
(c)	Any two from: • heat/energy losses (e.g. by convection, by conduction, to air, to surroundings) • incomplete combustion • evaporation of water • copper / can / beaker / thermometer /apparatus absorbs heat • flame moves around because of draughts	• non-standard conditions		2
(d) (i) (ii)	A B			1 1
(e)	M1 breaking bonds is endothermic / takes in heat/energy M2 making bonds is exothermic / gives out heat/energy M3 more heat/energy given out than taken in	more energy is given out when bonds are made than is taken in when bonds are broken for 3 marks more energy is given out when bonds are made than when bonds are broken for 1 mark		1 1 1

	IGNORE references to numbers/strengths of bonds			
			Total	9

Question number	Answer	Notes	Marks
3 a i	reactants labelled wrong way round / OWTTE	Accept manganese(IV) oxide is the solid OR hydrogen peroxide is the liquid Ignore just manganese(IV) oxide/hydrogen peroxide is wrongly labelled	1
ii	bung / cork	Accept stopper Ignore plug	1
iii	to prevent oxygen/gas from escaping OR (without a bung), oxygen/gas would escape/could not be collected	Do not penalise wrong gas, such as hydrogen	1
b	use a (gas) syringe	Accept collect in gas jar by displacement of air in place of syringe	1
c	2 2 (1)	Accept multiples and fractions	1

Question number	Answer	Notes	Marks
3 d	(a substance that) increases rate of reaction / speeds up reaction / decreases time of reaction is (chemically) unchanged (at the end) OR mass does not change	Ignore change/decrease in rate Ignore references to element / compound Accept is not used up / does not change Accept reference to lowering activation energy Ignore reference to alternative route Ignore references to yield Ignore reference to not reacting or taking part in reaction Ignore refs to being physically unchanged Ignore references to starting reaction Reject reference to providing/increasing energy for M2 Reject reference to incorrect statement such as removes impurities for M2	1 1
e	(approximately) vertical line between hydrogen peroxide and top of curve AND labelled activation energy / E_a	ignore arrowheads on vertical line	1
	curve starting from hydrogen peroxide line and ending at water + oxygen line AND peak below peak of original curve	Accept near misses, such to and from words Accept curve leaving or joining original curve Do not penalise more than one peak	1
		Total 9 marks	

Question number				Answer	Notes	Marks
4	a	i	M1	reversible (reaction) / goes forwards and/or backwards / can go in either direction	Ignore equilibrium	1
			M2	enthalpy/heat/energy change	Ignore kJ/mol Reject energy produced/released	1
		ii		exothermic / heat/energy given out/lost	Accept enthalpy in place of heat/energy Ignore references to temperature	1
	b		M1	two (vaguely) horizontal lines: one with reactants or their formulae AND one with products or their formulae	Ignore all curves and connecting lines Ignore line representing x-axis and any label Accept R for reactants and P for products	1
			M2	reactants (line) above products (line)	No penalty for products to left of reactants	1
					Accept formulae in place of words for reactants and products Do not penalise minor errors in formulae (e.g. NH instead of NH_3) or missing coefficients	
	c		M1	(effect of temp on rate) increased		1
			M2	(effect of temp on yield) decreased		1
			M3	(effect of catalyst on rate) increased		1
			M4	(effect of catalyst on yield) unchanged		1

Question number				Answer	Notes	Marks
4	d	i	M1	decreased	No ECF from increased / no effect Accept longer time for reaction Ignore references to equilibrium	1
			M2	particles further apart/more widely spaced / more space to move in / concentration decreases	Accept molecules Reject atoms/ions in M2 only If neither of M2 and M3 scored, accept fewer collisions with no reference to frequency or time	1
			M3	less frequent (successful) collisions / fewer (successful) collisions per second/minute	Accept more time between collisions Ignore decreased chance / probability / likelihood of collisions	1
					References to change in energy/speed of particles means M2 and M3 cannot be scored	
		ii	M1	shifted to right / more products / shifts in exothermic/forward direction	Ignore references to rate No ECF from shift to left / no change Accept forward reaction favoured	1
			M2	more (gas) moles/molecules on right	Accept fewer (gas) moles on left Accept favours side with more (gas) moles Accept 9 moles on left and 10 moles on right	1
	e			4 ( ) 2 4	Accept fractions and multiples	1
					Total	**15**