A-LEVEL
APPLIED SCIENCE

SC11 Controlling Chemical Processes

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Question	Answers	Additional Comments/Guidance	Mark
1(a)	Substance in natural / unprocessed state		1
1(b)(i)	Cost of setting up business, e.g. construction of manufacturing plant		1
1(b)(ii)	• *Direct*: e.g. crude oil / fuel • *Indirect*: e.g. sales / marketing / labour / maintenance / insurance / rent • *Capital*: e.g. fractionating tower	Accept any suitable answers	2 1 1
1(c)(i)	• Non-stop process • Products removed as reactants are added		1 1
1(c)(ii)	• Reactants are added, reaction occurs and • Products removed and vessel cleaned. Then process started again		1 1
1(c)(iii)	(Generally) faster Less labour intensive		1
1(d)(i)	• $2C_{35}H_{72} \rightarrow$ • $2C_{10}H_{22} + 25C_2H_4$	1 mark for each balancing no on RHS	2
1(d)(ii)	• 99 • 62.5		1 1
1(d)(iii)	• Moles chloroethene = 9000 ÷ 62.5 = 144 • Reaction is 1:1 so moles of 1,2-dichloroethane = 144 • Mass of 1,2-dichlorothane = 144 × 99 = 14 256 g or 14.256 kg	Correct answer with correct unit scores 3 Ecf from 1(d)(ii) 1 mk unit penalty for missing/ incorrect units Min 3sf -14.3kg or 14300g = 3mks	1 1 1
1(d)(iv)	Any **one** of • incomplete reaction • side reaction(s) • impure reagent(s)		1
Total			**19**

2(a)(i)	• vertical = number of molecules • horizontal = energy		1 1

2(a)(ii)	• Peak to right and starts at origin • Lower than original and asymptotic		1 1

2(a)(iii)	Activation energy is the minimum energy the particles require for a reaction to happen when they collide. When the temperature is increased, particles gain energy and move faster. They will therefore collide more frequently and more vigorously. A higher proportion of the particles will possess more energy than the activation energy. Therefore more of the collisions will be successful collisions.		5

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 1 (0−1 marks)

Answer is largely incomplete. It may contain valid points which are not clearly linked to an argument structure.
Unstructured answer
Errors in the use of technical terms, spelling, punctuation and grammar or lack of fluency

Level 2 (2−3 marks)

Answer has some omissions but is generally supported by some of the relevant points below:
- the argument shows some attempt at structure
- the ideas are expressed with reasonable clarity but with a few errors in the use of technical terms, spelling, punctuation and grammar

Level 3 (4−5 marks)

Answer is full and detailed and is supported by an appropriate range of relevant points such as those given below:
- argument is well structured with minimum repetition or irrelevant points
- accurate and clear expression of ideas with only minor errors in the use of technical terms, spelling and punctuation and grammar

examples of the points made in the response	extra information
• minimum energy required • for a reaction to happen • more energy • more collisions • higher proportion of particles with energy more than the activation energy • more successful collisions	

2(b)(i)	4		1

2(b)(ii)	• The rate of reaction is unaffected • by a change in concentration	Cannot score M2 without M1	1 1

2(b)(iii)	Rate $=k[L][M][N]^2$	All 4 correct = 3 marks 3 correct = 2 marks 1 or 2 correct = 1 mark	3

2(b)(iv)	• Expt 2: rate = 1.53	Accept correct answers given	1

	• Expt 3: [A] = 1.15(4) × 10^{-4} or 1.15(5) × 10^{-4} • Expt 4: [B] = 8.10 × 10^{-3}	to more than 3sf	1 1
2(b)(v)	*k* = rate ÷ $[A]^2[B]$ = (1.7 × 10^{-1}) ÷ [(1.6 × $10^{-4})^2$ (3.0× 10^{-3})] = 2.21 × 10^9	1 for rearrangement 1 for correct substitution Correct answer gets 3 marks	1 1 1
2(b)(vi)	$mol^{-2}\ dm^6\ s^{-1}$		1
Total			**22**

3(a)(i)	• Substance that alters the rate of a reaction • but does not get used up itself		1 1
3(a)(ii)	• Lowers the activation energy • The proportion of particles with an energy higher than the activation energy will increase		1 1
3(b)(i)	Any three from • timing device • gas syringe / measuring cylinder • bulb pipette / burette (to measure hydrogen peroxide solution) • thermometer / temperature probe	Alternative Top pan balance can be used in place of gas syringe/measuring cylinder	1 1 1
3(b)(ii)	Measure 50 cm^3 of hydrogen peroxide solution using a bulb pipette and transfer into a conical flask. Allow the contents to equilibrate at the required temperature in a thermostatically controlled water bath. Temperatures to be used will be 10°C (achieved using an ice bath), 20°C, 30°C, 40°C, and 50°C. At the instant 2 g of manganese dioxide is added the stopclock is started. The volume of gas given off is measured using the syringe. Readings are taken at 10 second intervals. The results are plotted on a graph. Volume on the *y*–axis, time on the *x*-axis. The gradient of the graph is proportional to the rate of the reaction.		5

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 1 (0−1 marks)

Answer is largely incomplete. It may contain valid points which are not clearly linked to an argument structure.
Unstructured answer
Errors in the use of technical terms, spelling, punctuation and grammar or lack of fluency

Level 2 (2−3 marks)

Answer has some omissions but is generally supported by some of the relevant points below:
- the argument shows some attempt at structure
- the ideas are expressed with reasonable clarity but with a few errors in the use of technical terms, spelling, punctuation and grammar

Level 3 (4−5 marks)

Answer is full and detailed and is supported by an appropriate range of relevant points such as those given below:
- argument is well structured with minimum repetition or irrelevant points
- accurate and clear expression of ideas with only minor errors in the use of technical terms, spelling and punctuation and grammar

3(b)(iii)	• Repeat the experiments • and identify anomalies		1 1
Total			**14**

4(a)	• General shape • Reactants and products labelled correctly • Products lower than reactants		1 1 1
4(b)(i)	Gain of oxygen / loss of electrons / loss of hydrogen		1
4(b)(ii)	• +4 • 0		1 1
4(b)(iii)	gloves		1
4(c)(i)	• Enthalpy / heat energy change • When one mole of a substance • is formed from its elements in their standard states		1 1 1
4(c)(ii)	• Elements (with state symbols) at bottom • All arrows pointing upwards • Correct coefficients for each element		1 1 1
4(c)(iii)	• $\Sigma\Delta H$f(products) − $\Sigma\Delta H$f(reactants) • =4(−393) +12(−286) − 4(+53) − 5(−20) • = –5116 kJ • Enthalpy change per mole = –5116 ÷ 4 = –1279 kJ mol^{-1}		1 1 1 1
Total			**17**

5(a)	• Reactants and products • in the same state		1 1
5(b)(i)	• A system in equilibrium • opposes the imposed change		1 1
5(b)(ii)	• The yield decreases • Forward reaction is exothermic • Reaction shifts to LHS to reduce temperature		1 1 1
5(b)(iii)	When there are different numbers of moles of gaseous molecules on each side of the equation		1
Total			**8**