

Question	Answer	Marks
1(a)	(sulfur-containing) fossil fuels;	1
(b)	M1 vanadium pentoxide/vanadium(V) oxide/ V_2O_5 (catalyst); M2 1–5 atmospheres (units required); M3 450 °C (units required); M4 $2SO_2 + O_2 \rightarrow 2SO_3$; M5 equilibrium/reversible reaction;	1 1 1 1 1
c)	$_2S_2O_7$;	1
(d)(i)	3 correct (2 marks) 2 correct (1 mark) bubbles / effervescence / fizzing; dissolves / disappears / <i>forms</i> a solution; blue (solution);	2
(d)(ii)	carbon dioxide and water and copper(II) sulfate;	1
(e)(i)	c	1
(e)(ii)	dehyd	1

Question	Answer	Marks
2(a)	fast(reaction; large(r) surface area;	1 1
(b)	(dm ³);	1
(c)	moves equilibrium to right; increases yield (of sulfur trioxide)/ uses up more sulfur dioxide;	1 1
(d)(i)	moves equilibrium to left; (forward reaction) exothermic;	1 1
(d)(ii)	d rate; molecules have less energy/ move slower; fewer collisions (per second)/ fewer particles have the activation energy / fewer collisions have the activation energy;	1 1 1
e)(i)	moves to right;	1
(e)(ii)	high yield at 2 atm;	1
(f)	vanadium(V) oxide/ vanadium pentoxide;	1
(g)	M1 dissolve/ react sulfur trioxide in (concentrated) sulfuric acid; add water to product of M1 ;	1 1

- 3 (a) Any **two** from:
bleach/making wood pulp/making paper
food/fruit juice/wine preservative
fumigant/sterilising/insecticide [2]
- (b) heating/roasting/burning (zinc sulfides) [1]
in air/oxygen COND on M1 [1]
- (c) (i) V_2O_5 [1]
- (ii) position of equilibrium shifts right/yield increases [1]
to save energy [1]
- (iii) faster reaction/rate [1]
more collisions per second/higher collision frequency [1]
fewer moles/molecules (of gas) on right [1]
(so) position of equilibrium shifts right/yield increases [1]
- (d) (the reaction is) too violent/too exothermic **or** produces mist/fumes (of acid) [1]
- [Total: 12]
- 4 (a) making fertilisers or pickling metals or making fibres or making phosphoric acid/phosphates
making dyes or making paints/pigments/dyes or making paper making plastics or making
detergents or tanning leather or battery acid. [1]
- (b) (i) add water (to yellow solid or to (anhydrous) iron(II) sulfate or to $FeSO_4$ or to products [1]
goes green [1]
- (ii) M1 Sulfur trioxide reacts with water to make sulfuric acid or equation [1]
M2 sulfur dioxide reacts with oxygen to form sulfur trioxide or equation [1]
- (iii) M1 = 2.07 Allow 2.1 or 2.0666...7
M2 = 62.8.g
M3 =(M2/152 =) 0.41(3)
M4 (=M1/M3) rounded to the nearest whole number $\times = 5$ [4]
- (c) (i) nitric acid or nitric(V) acid or HNO_3 [1]
- (ii) $2KNO_3 = 2KNO_2 + O_2$ [2]
Species (1)
Balance (1)

- 5 (a) (i) $S + O_2 \rightarrow SO_2$
 or sulfur burnt / roasted / heated in air to form sulfur dioxide [1]
- $2SO_2 + O_2 \rightleftharpoons 2SO_3$ [2]
 unbalanced = (1) only
- (catalyst) vanadium(V) oxide / vanadium pentoxide [1]
 (temperature) 440 to 460 °C [1]
 (dissolve) sulfur trioxide in sulfuric acid (to form oleum) [1]
 ignore comments about pressure
- (ii) add oleum to water [1]
- (b) $Ba(C_6H_{13}SO_3)_2 / (C_6H_{13}SO_3)_2Ba$ [
- (c) → magnesium hexanesulfonate + hydrogen [1]
- (ii) → calcium hexanesulfonate + water [1]
- (iii) $2C_6H_{13}SO_3H + Na_2CO_3 \rightarrow 2C_6H_{13}SO_3Na + CO_2 + H_2O$
- $C_6H_{13}SO_3Na = (1)$ [1]
 remaining species correct and equation balanced = (1) [1]
- (d) measure pH / add universal indicator [1]
 both acids have a low value / pH 0–2 / same colour / red [1]
 or
 measure rate with named reactive metal, Mg, Zn (1)
 both fast reactions (1)
 or
 measure rate using piece of insoluble carbonate, $CaCO_3$ (1)
 both fast reactions (1)
NOTE: must be insoluble for first mark
 or
 measure electrical conductivity (1)
 both good conductors (1)
- (ii) to have same concentration of H^+ / one acid is H_2SO_4 , the other is $C_6H_{13}SO_3H$ / sulfuric acid is dibasic, hexanesulfonic is monobasic [1]
- (iii) a strong acid is completely ionised, [1]
 a weak acid is partially ionised [1]

[Total: 17]