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91166







Mana Tohu Mātauranga o Aotearoa New Zealand Qualifications Authority

Level 2 Chemistry 2024

91166 Demonstrate understanding of chemical reactivity

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of chemical reactivity.	Demonstrate in-depth understanding of chemical reactivity.	Demonstrate comprehensive understanding of chemical reactivity.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and other reference material are provided in the Resource Booklet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (2/2). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement



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QUESTION ONE

Tiwai Point in the South Island of New Zealand extracts large amounts of aluminium sourced from an ore called bauxite, which contains the mineral aluminium(III) oxide, Al₂O₃. One step of the main extraction process is as follows:

$$Al_2O_3(s) + 2NaOH(aq) \rightarrow 2NaAlO_2(aq) + H_2O(\ell)$$

The graph below shows the mass of aluminium(III) oxide, Al₂O₃, as it reacts with 0.5 mol L⁻¹ NaOH.



Add a second line to the graph to predict the rate of decline in mass of aluminium(III) (a) (i) oxide if 2 mol L⁻¹ NaOH were used in the reaction instead.

Assume both reactions started with the same mass of ore.

With reference to the line you have drawn, explain the effect that this change in (ii) concentration of NaOH from 0.5 mol L⁻¹ to 2 mol L⁻¹ would have on the rate of this reaction.

In your answer you should include reference to:

- mass of Al₂O₃
- each section of the line
- collision theory.

in creasing the concentration will increase the rate at which the ALO3 reacts meaning the mass of Abo3 will decrease at a annicher rate. This is because increasing the concentration - the reactant means there are more particles

Chemistry 91166, 2024

3 to collide with the AlzOz SO ceactions will increase in likelihood 50 the rate be in creases of reaction will For the 0.5 mol L⁻¹ NaOH solution, calculate: (b) the hydronium ion, H₃Q⁺, concentration (i) the pH. (ii) >fogfa.g Chemistry 91166, 2024 10716

(c) Using the principles of collision and particle theories, explain why using a catalyst would help to increase the rate of production of sodium aluminium salt (NaAlO₂).

You should include an energy profile diagram to support your answer.

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Space for diagram

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Chemistry 91166, 2024

QUESTION TWO

Superphosphate fertiliser is manufactured in New Zealand using phosphorite rocks and sulfuric acid. The sulfuric acid is often produced on site, and includes a reaction involving oxygen, $O_2(g)$, sulfur dioxide, $SO_2(g)$, and sulfur trioxide, $SO_3(g)$, which is represented by the equilibrium constant expression below:

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$$K_{\rm c} = \frac{\left[\mathrm{SO}_3\right]^2}{\left[\mathrm{SO}_2\right]^2 \left[\mathrm{O}_2\right]} \qquad \qquad K_{\rm c} = 32.7 \text{ at } 25 \,^{\circ}\mathrm{C}$$

(a) (i)

Give the equation for this reaction. 2502020 2503co N

(ii)The reaction is set up and allowed to reach equilibrium.

Calculate the concentration of oxygen, O_2 , at equilibrium if the concentration of sulfur dioxide, SO_2 , is 0.17 mol L⁻¹ and sulfur trioxide, SO_3 , is 0.50 mol L⁻¹. 32.7 = 0.25 0.028944202=0.68 G.34+02=1

The reaction is set up differently, with concentrations of each component as indicated below. (b)

> $[SO_2] = 0.530 \text{ mol } L^{-1}$ $[O_2] = 0.710 \text{ mol } L^{-1}$ $[SO_3] = 0.620 \text{ mol } L^{-1}$

Using a calculation, explain why this reaction is not at equilibrium. (i)

Explain what must occur for equilibrium to be established. (ii)

Chemistry 91166, 2024

(c) Sulfuric acid, H_2SO_4 , can be manufactured using the following reaction:

$$SO_3(g) + H_2O(g) \rightleftharpoons H_2SO_4(g)$$

- (i) Using equilibrium principles, identify, then describe, the effect on the position of the equilibrium when:
 - water vapour, H₂O(g), is added to the reaction mixture *Circle your choice:*

Forward is favoured	No Change	Reverse is favoured
there	will be a	o change becaus
When	more the	sit added the
ceditarity in 1000 the	equilibre	um Will shift
for	mords to con	nterbalance
this chan	ge resulti	ng in there
being	of change	. In the position
	1	

• sodium hydroxide, NaOH(*aq*), is added to the reaction mixture. *Circle your choice:*

Forward is favoured

No Change

Reverse is favoured

12.2.2.

7 This reaction can be performed under high pressure. (ii)Explain why this is beneficial to the manufacturing process. DIESSURE WILL P 0 egction 99 prod wrod more 0 5 -01+19 NP EQSIN S R 51 9 ne s 9 Ith 010 ٢ 24 Jasbanz 6 (N) 8. MO rea chia e for word moons has N 9 favorned put of H250+ atoms EGAR 20 TOR OUT 0 orease 11 Chemistry 91166, 2024 10716

QUESTION THREE

(a) A reaction of HSO_4^- is shown below:

 $HSO_4^{-}(aq) + CO_3^{2-}(aq) \rightleftharpoons SO_4^{2-}(aq) + HCO_3^{-}(aq)$

(i) Identify the species acting as an acid and the species acting as a base in the above equation, and their conjugate pairs:

Acid: HSGQ	Conjugate base: 50^2
Base: (63-	Conjugate acid: 4003

(ii) Write the equilibrium constant expression, K_c for this process: $K_c = \frac{\sum O(1 - K_c)}{\sum O(1 - K_c)} H(O_{1} - K_c)$

(iii) This reaction was initially performed at 25 °C to determine the K_c value. When the reaction temperature was increased to 50 °C, the K_c value increased.

Explain whether the forward reaction is exothermic or endothermic.

this means that When the temperature was increase the forward reactions was forvoured meaning that it is that the there is

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)	Solu	Solutions of 0.1 mol L^{-1} concentration were made of each of the following three substances:						
		NH ₃ HNO ₃ NH ₄ Cl						
	(i)	Explain the pH of each of these solutions. Include:						
		• a choice of pH value for each substance from the options below						
		a classification for each substance						
		• any equations to explain the pH value.						
		pH options: 1–2 4–5 7 9–10 13–14						
		NH ₃ :						
		HNO ₃ :						
		NH ₄ Cl:						
		Question Three continues						
		on the next page.						

(ii) Discuss the conductivity of the solutions:

Note they are all equal in concentration.

In your answer you should:

- explain the requirements for a solution to conduct electricity
- compare the extent of conductivity of each substance
- reference the relevant equations from your previous answer to part (b)(i).

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SPARE DIAGRAMS

If you need to redraw your response to Question One (a)(i), use the graph below. Make sure it is clear which answer you want marked.



Achievement

Subject: Chemistry

Standard: 91166

Total score: 10

Q	Grade score	Marker commentary	
One	А3	a. (i) The student has drawn the 2 molL ⁻¹ correctly and touched the x-axis.	
		ii. The student has stated that the increase in concentration will increase the rate of reaction. There is no other A evidence provided.	
		b. (i) and (ii) not attempted.	
		c. Student has stated that there is an alternative pathway, and a decrease in activation energy (A point), linked this to overcoming activation energy, and increase rate of reaction (M point). To get the excellence student needed to refer to the 'increase in frequency of successful collisions' and a correctly labelled graph.	
Two	M5	a. (i) Correct equation with states	
		(ii) Student has crossed out the answer, which was incorrect	
		b. (i) Student has a correct calculation with 3 significant figures	
		(ii) Student stated 1.93 ≠ 32.7, which is evidence that the new value is not equal to Kc (m point). Student has not indicated how to re-establish equilibrium for other M or E points.	
		c. (i) Student has not circled 'forward is favoured' for either question. The A point was not awarded to the student as their statement contradicts itself.	
		(ii) Students states 'favours the side with less gas molecules. This means the forward reaction will be favoured'. This meets the M criteria, but can't go higher as 'particles' is only accepted at M level.	
Three	N2	a. (i) Correct conjugate pairs (A point)	
		(ii) Incorrect Kc expression	
		(iii) Students has linked the forward reaction to being endothermic for the A point	
		b. No response for (i) or (ii)	