

Unit exam

Unit 3 Equilibrium, acids and bases and redox reactions

Name: _____

Class: _____

Time permitted: 70 minutes

	Section	Number of questions	Marks available	Marks achieved
A	Multiple choice	30	30	
B	Short answer	10	40	
	Total		70	

Grade: _____

Scale:

A+	66–70	A	60–65	B	50–59	C	40–49	D	35–39	E	21–34	UG	0–20
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Comments:

Section A Multiple choice (30 marks)

Section A consists of 30 questions, each worth one mark. Each question has only one correct answer. Circle the correct answer. Attempt all questions. Marks will not be deducted for incorrect answers. You are advised to spend no more than 30 minutes on this section.

- 1 What is the equilibrium expression for dissolving solid calcium chloride?

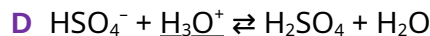
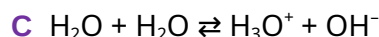
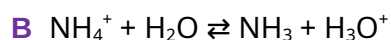
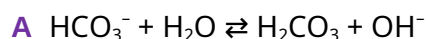
A
$$\frac{[\text{Ca}^{2+}][\text{Cl}^-]^2}{[\text{CaCl}_2][\text{H}_2\text{O}]}$$

B
$$\frac{[\text{CaCl}_2][\text{H}_2\text{O}]}{[\text{Ca}^{2+}][\text{Cl}^-]^2}$$

C
$$[\text{Ca}^{2+}][\text{Cl}^-]^2$$

D
$$\frac{[\text{Ca}^{2+}][\text{Cl}^-]^2}{[\text{CaCl}_2]}$$

- 2 In which of the following equilibria does the underlined act as a base?



- 3 Element Q has the following six successive ionisation energies (in kJ mol^{-1}).

589.8; 1145.4; 4912.4; 6491; 8153; 10 496

What will be the formula of a compound when it reacts with fluorine?



- 4 The equilibrium quotient, K, will be the same as the reaction quotient, Q, at equilibrium. Which of the following is also correct?

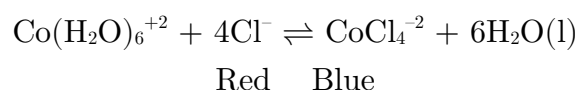
A $Q > K$, then there are more products than reactants.

B $Q > 1$, then there are more reactants than products.

C $Q < K$, then there are less products than reactants.

D $K < 1$, then there are more products than reactants.

- 5 Cobalt chloride dissolves in dilute hydrochloric acid to form an equilibrium.



The red and blue colours mix to form a purple solution. What change will cause a redder solution to form?

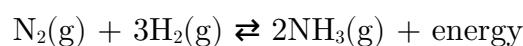
- A** The addition of a catalyst
- B** Adding a few drops of concentrated HCl
- C** Adding few millilitres of silver nitrate solution
- D** The addition of water

6 A student carries out a titration and obtains the following results.

Final reading (mL)	23.10	22.55	22.60	22.00	22.40
Initial reading (mL)	0.10	1.00	1.10	1.65	0.85

What titration figure should she use in her subsequent calculation?

- A** 21.24 mL
 - B** 21.59 mL
 - C** 21.53 mL
 - D** 21.35 mL
- 7** Which of the following oxides would be acidic?
- A** Na₂O
 - B** MgO
 - C** Al₂O₃
 - D** CO
- 8** Which one of the following, when diluted, is a weak electrolyte?
- A** Ca(OH)₂
 - B** HNO₃
 - C** CH₃COOH
 - D** NaOH
- 9** What is the pH of a 2 mol L⁻¹ solution of Ca(OH)₂?
- A** 0.3
 - B** 0.6
 - C** 13.4
 - D** 13.7
- 10** A reaction can be sped up in several ways. Which method from the list below would *not* affect the rate of reaction?



- i** Temperature change
 - ii** Pressure change
 - iii** Adding a catalyst
 - iv** Adding more reactants
- A** i only
 - B** i and ii
 - C** iv only

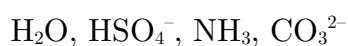
D None of the above

- 11** Successive ionisation energies can determine which group an element belongs to. To which group does this element belong?

First	787 kJ mol ⁻¹
Second	1577 kJ mol ⁻¹
Third	3232 kJ mol ⁻¹
Fourth	4356 kJ mol ⁻¹
Fifth	16 091 kJ mol ⁻¹

- A** 2
B 13
C 14
D 15

- 12** Which is a correct conjugate pairing of the following, in order?



- A** OH^- , H_2SO_4 , NH_4^+ , CO_2
B H_3O^+ , HSO_4^{--} , NH_2 , HCO_3^-
C OH^- , SO_4^{2-} , NH_4^+ , HCO_3^-
D H_3O^+ , SO_4^{2-} , NH_4^+ , H_2CO_3

- 13** In an equilibrium reaction:

- A** the amount of reactants and products are the same.
B products will not form if reactants are favoured.
C all reactants become products.
D the rate of forward and reverse reactions are the same.

- 14** What is the pH of a 5 mol L⁻¹ solution of HCl?

- A** 12.5
B 0.5
C 0.7
D 1.4

- 15** Which of the following are in order of increasing ionisation energy?

- A** Be, B, C, N, O, F
B F, O, N, C, B, Be
C B, Be, C, O, F, N
D N, O, F, Be, B, C

- 16** Which of the following statements is *not* true?

- A** Bases are cations, anions or molecules that donate protons to other species.
B The ability to accept protons from other species is a property of bases.
C A base is produced when a cation, anion or molecule donates a proton.

- D** When a proton is donated by one species to another, it is an acid–base reaction.
- 17** The K_w of water at 50°C is 5.476×10^{-14} . What is pH of water at this temperature?
- A** 6.6
B 7.0
C 7.4
D 3.2
- 18** In which group would all three oxides be classified as acidic oxides?
- A** CO_2 , SiO_2 , CuO
B Na_2O , SiO_2 , CO_2
C SO_2 , NO_2 , SO_3
D CaO , SO_2 , SO_3
- 19** Which of the following reactions would *not* change when the pressure changed?
- A** $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
B $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2\text{O}(\text{g})$
C $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$
D $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
- 20** Which one of the following compounds is a triprotic acid?
- A** Sulfuric acid
B Ammonia
C Nitric acid
D Phosphoric acid
- 21** Which is true for the following reaction?
- $$\text{CuO} + \text{H}_2 \rightleftharpoons \text{Cu} + \text{H}_2\text{O}$$
- A** CuO is a reductant.
B H_2O is the reductant.
C Cu is the oxidant.
D H_2 is oxidised.
- 22** Which is the correct equilibrium reaction for this equilibrium constant expression?
- $$K = \frac{[\text{NOCl}]^2}{[\text{NO}]^2[\text{Cl}_2]}$$
- A** $\text{Cl}_2 + \text{NO} \rightleftharpoons \text{NOCl}$
B $2\text{NOCl} \rightleftharpoons \text{Cl}_2 + 2\text{NO}$
C $\text{NOCl} \rightleftharpoons \text{Cl}_2 + \text{NO}$
D $\text{Cl}_2 + 2\text{NO} \rightleftharpoons 2\text{NOCl}$
- 23** Which of the following is false for equilibrium?
- A** The speed of product formation is equivalent to the speed of reactant formation.

- B** It never ceases.
 - C** Concentrations of all species are equal.
 - D** Concentrations are unchanging.
- 24** Water is not included in equilibrium expressions. Which answer does *not* explain this?
- A** It is constant.
 - B** Its concentration is unchanging.
 - C** It plays no part in facilitating the reaction.
 - D** It is a spectator.
- 25** In electrochemical cells, the salt bridge:
- A** completes the circuit by allowing the ions to move between the two half-cells.
 - B** completes the circuit by allowing electrons to move between the two half-cells.
 - C** completes the circuit by allowing a current to flow from the anode to the cathode.
 - D** completes the circuit by allowing a current to flow from the cathode to the anode.
- 26** When titrating, what should the burette be rinsed with?
- A** Distilled water
 - B** Dilute acid
 - C** Solution to be pipetted
 - D** Dilute alkali
- 27** What should a conical flask used in titration be rinsed with?
- A** Distilled water
 - B** Dilute acid
 - C** Solution to be pipetted
 - D** Dilute alkali
- 28** Which indicator would you use for titrating dilute potassium hydroxide (0.01 mol L^{-1}) and dilute ethanoic acid (0.01 mol L^{-1})?
- A** Methyl orange (pH range: 3.1–4.4)
 - B** Methyl red (pH range: 4.4–6.2)
 - C** Bromothymol blue (pH range: 6.0–7.6)
 - D** Phenolphthalein (pH range: 8.3–10.0)
- 29** Methanol can be made as follows:
- $$\text{CO(g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)} + \text{heat}$$
- How would you increase product?
- A** Increase the temperature.
 - B** Decrease the temperature.
 - C** Reduce the $[\text{CO}]$.

D Reduce the pressure.

30 In order of electronegativity, first ionisation energy and atomic size, what are the trends in group 1?

A Decreases; decreases; decreases

B Decreases; increases; increases

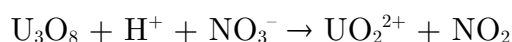
C Decreases; decreases; increases

D Increases; decreases; decreases

Section B Short answer (40 marks)

Section B consists of 10 questions. Write your answers in the space provided. You are advised to spend 40 minutes on this section.

1 Pitchblende, U_3O_8 , is a naturally occurring ore of uranium. The following reaction occurs when the ore is processed:

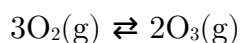


a Balance this redox reaction.

b Calculate the oxidation number of U in UO_2^{2+} . (Show your working.)

(3 + 1 = 4 marks)

2 For the following endothermic reaction, list all the ways to decrease the product and increase the reactant species.



(= 4 marks)

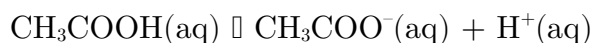
3 a What are the main trends in atomic radius?

b Explain the trends across a row in the periodic table and down a group.

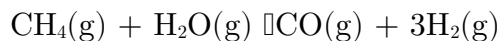
(1 + 2 = 3 marks)

4 For each of the following reactions, predict what will occur when the imposed change occurs.

a Sodium ethanoate is added to:



b Pressure is increased on:



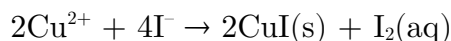
c Acid is added to:



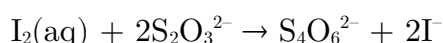
d Describe the colour change that would occur for the above reaction if the chromate ions are yellow and dichromate ions are orange.

(1 + 1 + 1 + 1 = 4 marks)

5 The amount of copper in a solution of a copper(II) salt can be determined by reacting it with an excess of an iodide solution, described by the balanced oxidation-reduction equation below:



The resulting iodine solution is then titrated with thiosulphate as shown in the balanced oxidation-reduction equation:



In an analysis, 0.245 g of a copper salt produced a solution of iodine which required 24.8 mL of thiosulphate solution (0.060 mol L⁻¹) to reach an endpoint.

a Calculate the number of moles of iodine formed.

b Calculate the number of moles of copper(II) ions that reacted with the iodide solution.

c Calculate the mass % copper(II) ions in the copper salt.

(2 + 2 + 2 = 6 marks)

- 6 This table shows the melting points for the elements in period 3.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting point (K)	371	923	933	1680	317	392	172	84

In terms of structure and bonding explain why:

- a silicon has a high melting point
- b the melting point of sulfur is higher than phosphorous.

(2 + 2 = 4 marks)

- 7 a Define the term 'electronegativity'.
- b State and explain the electronegativity across period 3.

(1 + 2 = 3 marks)

- 8 Calculate the pH of the following solutions.

- a 0.2 mol L⁻¹ HCl
- b 0.05 mol L⁻¹ H₂SO₄
- c 0.05 mol L⁻¹ NaOH
- d 20 g L⁻¹ KOH
- e H₂O at 373K given that at 373K, $K_w = 5.13 \times 10^{-13}$.

- f** Explain why the water is still considered neutral at the pH in the last question (part **e**).

(1 + 1 + 1 + 1 + 1 + 1 = 6 marks)

- 9** Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7^{2-}$) is used to analyse hydrogen peroxide solutions. Use half-equations to construct the redox equation for the reaction that occurs when potassium dichromate solution is added to a solution containing hydrogen peroxide in acid.

(= 2 marks)

- 10** List the following 0.1 M solutions in order of increasing pH.

CH_3COOH , NaOH , HCl , CH_3COONa , H_2SO_4 , $\text{CH}_3\text{CH}_2\text{OH}$

Explain your answers and give equations for each solution as it dissolves in water.

(= 4 marks)