**Year 12 ATAR Chemistry**

Task 2: Equilibrium & Acid-Base Chemistry Test

Weighting: 5% of Year Grade

NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |
| --- | --- | --- | --- |
| **SECTION** | **NUMBER OF QUESTIONS** | **AVAILABLE MARKS** | **MARK** |
| Multiple Choice | 10 | 10 |  |
| Short Answer | 4 | 35 |  |
| Extended Response | 1 | 13 |  |

**Instructions:**

* You will be given 55 minutes’ working time to complete the test.
* Multiple choice answers should be given on the answer sheet provided.
* Short response questions should be written in the spaces provided.
* Any calculations must show FULL WORKING and be stated to the appropriate number of significant figures or marks will be deducted.
* Use BLACK or BLUE pen only.
* Scientific calculators are permitted for this test.
* A Chemistry Data Sheet will be provided with this test.

**SECTION A: MULTIPLE CHOICE SECTION (10 marks)**

INSTRUCTIONS

Graphical user interface, text, application, email

Description automatically generated

Text

Description automatically generated with low confidenceText

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**Question 1**

The equilibrium constant expression for a particular reaction is as follows.

K =

The reaction could be:

1. 2CO*(g)* + 2H2*(g)* ⇌ CH4*(g)* + CO2*(g)*
2. C*(s)* + H2O*(g)* ⇌ H2*(g)* + CO*(g)*
3. H2O*(g)* + CO*(g)* ⇌ CO2*(g)* + H2*(g)*
4. CH4*(g)* + 2O2*(g)* ⇌ CO2*(g)* + 2H2O*(g)*

**Question 2**

A reaction vessel has the energy profile diagram shown below

Chart, line chart

Description automatically generated

Which of the following represents the energy profile of the **reverse reaction**?

**Activation energy (kJmol-1) ΔH ((kJmol-1)**

1. 50 +10
2. 60 +10
3. 60 -10
4. 50 -10

**Question 3**

Consider the information in the table below regarding three different monoprotic acids.

|  |  |
| --- | --- |
| **Acid** | **Ka** |
| Formic acid | 1.82 x 10-4 |
| Hydrofluoric acid | 6.76 x 10-4 |
| Propionic acid | 1.35 x 10-5 |

If separate 0.5 mol L-1 solutions of these three acids were tested with a pH meter, at the same temperature, which would have the highest pH?

1. Formic acid.
2. Hydrofluoric acid.
3. Propionic acid.
4. More information is required.

**Question 4**

In terms of acid/base theory a neutral solution requires

(a) [H3O+] = [OH–] = 0.00 mol L-1

(b) pH = 7 at STP

(c) [H3O+] = [OH–]

(d) [H3O+] = 1.0 x 10-7

**Question 5**

Which two of the following pairs of solutions could form buffers?

1. HCℓ / Cℓ–
2. NH3 / NH4Cℓ
3. H2SO4 / HSO4–
4. CH3COOH / CH3COO–

(a) i and ii only

(b) ii and iii only

(c) iii and iv only

(d) ii and iv only

**Question 6**

The following concentration-time graph refers to a mixture of three gases, P. Q and R, in an enclosed 5.0 L container. At time, *t1*, the mixture is heated.

Chart

Description automatically generated with medium confidence

The equilibrium system that represents the graph is

1. P(g) ⇌ 2Q(g) + R(g) and the forward reaction is exothermic.
2. 2Q(g) ⇌ P(g) + R(g) and the forward reaction is endothermic.
3. 2Q(g) + R(g) ⇌ P(g) and the forward reaction is exothermic.
4. P(g) + 2Q(g) ⇌ R(g) and the forward reaction is endothermic.

**Question 7**

Consider the following buffer system.

H2PO4–(aq) + H2O(ℓ) ⇌ HPO42–(aq) + H3O+(aq)

Which one, if any, of the following will be higher after a small amount of strong base is added and equilibrium is re–established?

(a) [H2PO4–(aq)]

(b) [OH–(aq)]

(c) [H3O+(aq)]

(d) none of these will be higher

**Question 8**

For the reaction N2*(g)* + 3H2*(g)* ⇌ 2NH3*(g)* ΔH = -92.3 kJ mol-1

1. A catalyst increases the number of collisions between the reactants.
2. The activation energy of the forward reaction is greater than the activation energy of the reverse reaction.
3. A catalyst reduces the activation energy of the forward and backward reactions by the same proportion.
4. The rate of the forward reaction increases when the temperature increases.

**Question 9**

Energy is needed to break chemical bonds. At very high temperatures iodine partially dissociates to give an equilibrium mixture according to the equation:

I2(g) ⇌ 2 I(g)

Which one of the following statements is **true**?

(a) The partial pressure of the molecular iodine is independent of the temperature.

(b) The equilibrium constant has a fixed value and does not change as the temperature is altered.

(c) The partial pressure of the molecular iodine increases as the temperature is raised.

(d) The equilibrium constant for this reaction increases as the temperature is raised.

Question 10

A student had five different 0.2 mol L-1 solutions on her lab bench. They were;

* + - nitric acid, HNO3(aq)
    - zinc chloride, ZnCl2(aq)
    - lithium hydrogencarbonate, LiHCO3(aq)
    - potassium hydroxide, KOH(aq)
    - ammonium chloride, NH4Cl(aq)

Rank these solutions in order of **increasing** pH (i.e. lowest to highest).

1. HNO3 < NH4Cl < ZnCl2 < LiHCO3 < KOH
2. KOH < NH4Cl < ZnCl2 < LiHCO3 < HNO3
3. HNO3 < LiHCO3 < NH4Cl < ZnCl2 < KOH
4. KOH < ZnCl2 < LiHCO3 < NH4Cl < HNO

**SECTION B: SHORT ANSWER SECTION (35 marks)**

**Question 11**

Methanol is a very useful fuel. It can be manufactured from biogas. The main reaction in methanol production from biogas is represented by the following equation.

CO*(g)* + 2H2*(g)* ⇌ CH3OH*(g)* ΔH < 0

This reaction requires the use of a catalyst to maximise the yield of methanol produced in optimal conditions. The energy profile diagram below represents the uncatalyzed reaction.

Diagram

Description automatically generated

1. On the energy profile diagram above, sketch how the catalyst would alter the reaction pathway.

[1 mark]

1. How does the reaction temperature affect the yield of methanol from biogas? In your answer refer to collision theory. [5 marks]

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1. How does the reaction pressure affect the yield of methanol from biogas? In your answer refer to Le Chatelier’s Principle. [2 marks]

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**Question 12**

Consider the red cabbage indicator colour chart shown below.

Table, calendar

Description automatically generated

a) Assuming complete ionisation, calculate the pH of a 0.050 mol L-1 solution of sulfuric acid and state what colour the red cabbage indicator would be in this solution. [3 marks]

b) When an unknown concentration of barium hydroxide was added to the cabbage indicator, it turned yellow. Estimate the approximate concentration of the barium hydroxide solution. [4 marks]

**Question 13**

0.100 mol L-1 barium hydrogen carbonate solution is added to excess 0.100 mol L-1 sulfuric acid solution.

1. Write the balanced equation, with appropriate state symbols, for the reaction that takes place between the barium hydrogen carbonate and the sulfuric acid. [3 marks]
2. Predict all observations, if any, that could be made (i) while the reactants are mixed together and (ii) afterwards. [3 marks]

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1. Predict any observation/s that would be different if excess 0.100 mol L-1 hydrochloric acid was used instead of the 0.100 mol L-1 sulfuric acid. [1 mark]

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Acids and bases have lots of uses both in the home and industrially. One example is the use of milk of magnesia, Mg(OH)2, as an antacid to neutralize stomach acid. This is shown in the equation below:

Mg(OH)2 *(s)* + 2HCl *(aq)* 🡪 MgCl2 *(aq)* + 2H2O *(l)*

1. Complete the table below to identify the conjugate acid-base pairs in the equation above. [2 marks]

|  |  |
| --- | --- |
| Acid: | Conjugate Base: |
| Base: | Conjugate Acid: |

**Question 14**

The graph drawn below shows the concentrations of the three substances in the reacting system given by the following equation, plotted against time.

COCl2(g) Cl2(g) + CO(g) ΔH = +108 kJ

Diagram

Description automatically generated

a) Describe the different events that disturbed the equilibrium, as shown on the graph, at each of the following points in time. [3 marks]

|  |  |
| --- | --- |
| **Time** | **Event that disturbed the equilibrium** |
| **4 mins** |  |
| **10 mins** |  |
| **14 mins** |  |

b) Show, on the axes below, how both the forward reaction rate (solid line) and reverse reaction rate (dashed line) change, from before the event that occurred at the 4-minute mark until after equilibrium was re-established at the 8-minute mark. [4 marks]

Reaction

Rate

4 min 8 min Time

c) The system has returned to equilibrium by the 12-minute mark. Write the equilibrium constant expression for this system. [2 marks]

1. How would the value of the equilibrium constant change, compared to the value at the 12-minute mark, at each of the following times? Circle your answer. [2 marks]

(i) 2 minutes **lower same higher**

(i) 18 minutes **lower same higher**

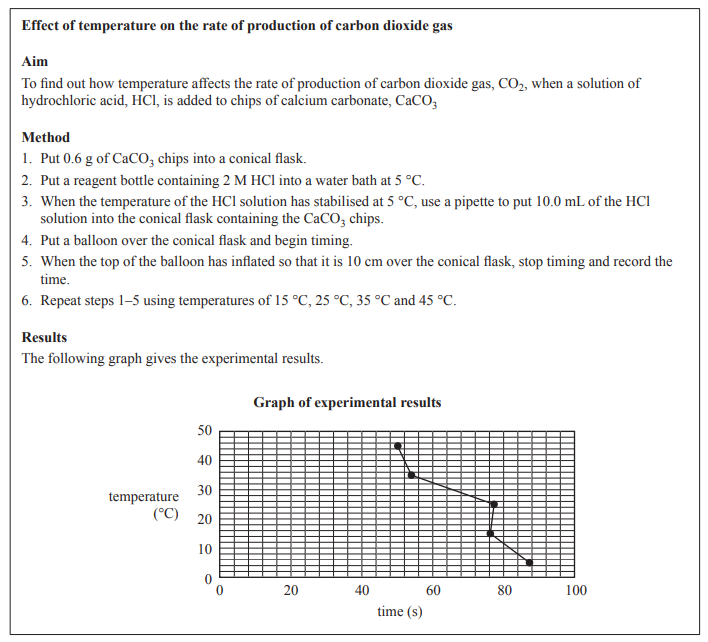
**SECTION C: EXTENDED RESPONSE SECTION (13 marks)**

**Question 15**

A student decided to investigate the effect of temperature on the rate of the following reaction.

2HCl*(aq)* + CaCO3*(s)* → CaCl2*(aq)* + H2O*(l)* + CO2*(g)*

Part of the student’s experimental report is provided below.



1. List two (2) safety precautions the student should take while doing this investigation. [2 marks]

One: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Two: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What is the independent variable. [1 mark]

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1. What is the dependent variable and how is it measured. [2 marks]

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1. **Predict** the relationship between the independent variable and the dependent variable. Explain your prediction. [3 marks]

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1. Is the graph of the students’ results consistent with your prediction? Give your reasoning. [1 mark]

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1. Identify two ways in which the graph could have been presented differently to better illustrate the relationship between the independent variable and the dependent variable. [2 marks]

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g) Identify one (1) way you could change the experiment to reduce an error associated with the method and classify the error addressed as a systemic or random error. [2 marks]

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**END OF TEST**