

**Chemistry**  
**Higher level**  
**Paper 2**

Practice paper

**Topic: Equilibrium**

**Chemistry**

**Higher level**

**Paper 2**

Specimen paper

2 hours 15 minutes

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**Instructions to candidates**

- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is [65 marks].

1. Nitrogen dioxide,  $\text{NO}_2(\text{g})$ , reversibly dimerizes to form dinitrogen tetroxide,  $\text{N}_2\text{O}_4(\text{g})$ :  $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$  with  $\Delta H^\ominus = -57 \text{ kJ mol}^{-1}$ . An equilibrium mixture in a rigid  $1.00 \text{ dm}^3$  flask contains  $0.200 \text{ mol}$  of  $\text{NO}_2$  and  $0.800 \text{ mol}$  of  $\text{N}_2\text{O}_4$  at a specific temperature. Phosgene gas decomposes at elevated temperatures:  $\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$ . At  $1000 \text{ K}$ ,  $0.400 \text{ mol}$  of  $\text{COCl}_2$  is placed in a  $2.00 \text{ dm}^3$  flask. At equilibrium, the concentration of  $\text{Cl}_2$  is found to be  $0.120 \text{ mol dm}^{-3}$ .

(a) Calculate the value of the equilibrium constant,  $K_c$ , for this reaction at this temperature.

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(b) The mixture is subsequently cooled. Predict and explain the effect on both the value of  $K_c$  and the total pressure inside the rigid flask.

[3]

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2.

(a) Calculate the equilibrium concentration of  $\text{COCl}_2$ .

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(b) Calculate the value of  $K_c$  at  $1000 \text{ K}$ .

[2]

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3. Calcium carbonate decomposes upon heating:  $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ .

(a) Formulate the equilibrium constant expression for  $K_c$ . Explain why solid components are omitted. **[2]**

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4. The relationship between  $K$  and temperature can be analyzed using the equation:  $\ln K = -\Delta H^\ominus / RT + \Delta S^\ominus / R$ .

(a) For an exothermic reaction, state and explain the effect of increasing temperature on the value of  $K$ , referencing the mathematical equation above.

[3]

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5. A weak acid dissociates according to  $\text{HA}(\text{aq}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{A}^-(\text{aq})$  with  $K_c = 1.0 \times 10^{-5}$ . You are calculating the pH of a  $0.10 \text{ mol dm}^{-3}$  solution.

(a) During calculations, the change  $x$  is often assumed to be negligible compared to the initial concentration of HA. Justify mathematically why this approximation is valid here.

[2]

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6. For the reaction:  $a\text{A}(\text{g}) \rightleftharpoons b\text{B}(\text{g})$ , if the total pressure of the system at equilibrium is tripled by severely reducing the volume, the equilibrium shifts to the left.

(a) Deduce the relationship between the stoichiometric coefficients  $a$  and  $b$ .

[1]

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7. A reaction mixture contains concentrations such that  $Q_c = 50$ . The  $K_c$  for the reaction is exactly 50.

(a) Describe the macroscopic and microscopic behavior of the system at this exact moment.

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