**Equilibria – Homework 2**

**1.**

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| Summarised directions for recording responses to multiple completion questions | | | |
| **A** (i), (ii) and (iii) only | **B** (i) and (iii) only | **C** (ii) and (iv) only | **D** (iv) alone |

The following equilibrium is established:

2CrO42– (aq) + 2H+(aq)  Cr2O7 2–(aq) + H2O(l)

Which of the following statements is/are true concerning this equilibrium?

(i) Dilution of the system with water will result in an increase in the concentration of CrO42– (aq) ions relative to that of Cr2O7 2–(aq).

(ii) The addition of a catalyst will result in an increase in the concentration of Cr2O7 2–(aq) ions.

(iii) The forward and backward reactions are proceeding at the same rate.

(iv) The position of the equilibrium is unaffected by the addition of a dilute acid.

For Questions **2-5,** more than one of the options given may be correct. Select your answer by means of the following code

**A** if (1), (2) and (3) only are correct

**B** if (1) and (3) only are correct

**C** if (2) and (4) only are correct

**D** if (4) alone is correct

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| Directions summarised | | | |
| **A** | **B** | **C** | **D** |
| (1), (2) and (3) only correct | (1) and (3) only correct | (2) and (4) only correct | (4) only correct |

**2.** When left to stand, a mixture of ethanoic acid and ethanol reaches equilibrium as shown in the following equation.

CH3COOH(l) + CH3CH2OH(l)  CH3COOCH2CH3(l) + H2O(l) *H* = –2 kJ mol–1

The amount of CH3CH2OH in a mixture at equilibrium can be increased by

(1) adding more water.

(2) raising the temperature.

(3) adding dilute aqueous sodium hydroxide.

(4) adding a catalyst.

**3.** Methanol can be synthesised in the gas phase from methane and steam as shown in the reactions below.

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| **Reaction** | **Equation** | ***H*****/kJ mol–1** | ***S*****/J K–1 mol–1** |
| **P** | CH4(g) + H2O(g)  3H2(g) + CO(g) | +206 | +216 |
| **Q** | CO(g) + 2H2(g)  CH3OH(g) | –91 | –222 |
| **R** | CO(g) + H2O(g)  CO2(g) + H2(g) | –41 | –42 |
| **S** | CO2(g) + 3H2(g)  CH3OH(g) + H2O(g) | –49 | –180 |

In which of these reactions is a high equilibrium yield favoured by both low temperature and high pressure?

(1) Reaction **P**

(2) Reaction **Q**

(3) Reaction **R**

(4) Reaction **S**

**4.** The following information concerns the gas-phase formation of nitrogen monoxide.

N2(g) + O2(g)  NO(g) *H*= +91 kJ mol–1

A series of experiments was carried out in a reaction vessel at constant temperature.  
When the initial pressure of both gases was increased by a factor of 2, the initial rate of reaction increased by a factor of 8.  
When the initial pressure of N2 was doubled while that of O2 remained constant, the initial rate of reaction increased by a factor of 2.

Which of the following statements is/are true?

(1) The reaction is first order with respect to nitrogen.

(2) The yield increases if the pressure is increased.

(3) The rate increases if the pressure is increased.

(4) The equilibrium constant decreases if the temperature is increased.

**5.** Look at the question above. Which of the following statements is/are also true?

(1) The equilibrium constant has the units mol–1 dm3.

(2) Increasing the pressure of both gases by a factor of 3 increases the rate by a factor of 27.

(3) The equilibrium constant increases if the pressure is decreased.

(4) The rate constant has the units mol–2 dm6 s–1.

**6.** At a temperature of 107°C, the reaction

CO(g) **+** 2H2(g)  CH3OH(g)

reaches equilibrium under a pressure of 1.59 MPa with 0.122 mol of carbon monoxide  
and 0.298 mol of hydrogen present at equilibrium in a vessel of volume 1.04 dm3.

Use these data to answer the questions that follow.

(a) Assuming ideal gas behaviour, determine the total number of moles of gas present. Hence calculate the number of moles of methanol in the equilibrium mixture.

*Total moles.*.................................................................................................................

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*Moles of methanol*......................................................................................................

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(3)

(b) Calculate the value of the equilibrium constant, *K*c, for this reaction and state its units.

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(3)

(Total 6 marks)

**7.** (a) The diagram below shows the effect of temperature and pressure on the equilibrium yield of the product in a gaseous equilibrium.



(i) Use the diagram to deduce whether the forward reaction involves an increase or a decrease in the number of moles of gas. Explain your answer.

*Change in number of moles* .............................................................................

*Explanation* ......................................................................................................

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(ii) Use the diagram to deduce whether the forward reaction is exothermic or endothermic.  
Explain your answer.

*The forward reaction is* ...................................................................................

*Explanation* ......................................................................................................

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(6)

(b) When a 0.218 mol sample of hydrogen iodide was heated in a flask of volume V dm3, the following equilibrium was established at 700 K.

2HI(g)  H2(g) + I2(g)

The equilibrium mixture was found to contain 0.023 mol of hydrogen.

(i) Calculate the number of moles of iodine and the number of moles of hydrogen iodide in the equilibrium mixture.

*Number of moles of iodine*................................................................................

*Number of moles of hydrogen iodide*................................................................

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(ii) Write an expression for *K*c for the equilibrium.

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(iii) State why the volume of the flask need not be known when calculating a value for *K*c.

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(iv) Calculate the value of *K*c at 700 K.

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(v) Calculate the value of *K*c at 700 K for the equilibrium

H2(g) + I2(g)  2HI(g)

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(7)

(Total 13 marks)