7 Dinitrogen tetroxide, $N_2O_4(g)$, and nitrogen dioxide, $NO_2(g)$, coexist in the following equilibrium.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57\,kJ\,mol^{-1}$$

A chemist adds 4.00 mol NO_2 to a container with a volume of 2.00 dm^3. The container is sealed, heated to a constant temperature and allowed to reach equilibrium.

The equilibrium mixture contains 3.20 mol NO_2.

(a) Calculate the value for K_c under these conditions.

[5]

(b) The experiment is repeated but the pressure in the container is doubled.

Explain in terms of K_c the effect on the concentrations of NO_2 and N_2O_4 when the mixture has reached equilibrium.

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..... **[3]**

[Total: 8]

5 Methanol can be prepared industrially by reacting together carbon monoxide and hydrogen. This is a reversible reaction:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -94\,kJ\,mol^{-1}$$

- A chemist mixes together 0.114 mol CO(g) and 0.152 mol $H_2(g)$ in a container.
- The container is pressurised and then sealed. The total volume is 200 cm^3.
- The mixture is heated to 500 K and left to reach equilibrium.
  The volume of the sealed container is kept at 200 cm^3.
- The chemist analyses the equilibrium mixture and finds that 0.052 mol CH_3OH has formed.

(a) Calculate the value of K_c, including units, for the equilibrium at 500 K.

Give your answer to **three** significant figures.

K_c = ... units ..... **[6]**

(b) The chemist repeats the experiment using the same initial amounts of CO and H_2.
The same procedure is used but the mixture is heated in the 200 cm^3 sealed container to a higher temperature than 500 K.

As the gas volume is kept at 200 cm^3, the increased temperature also increases the pressure.

- Explain why it is difficult to predict how the yield of CH_3OH would change.
- Explain what happens to the value of K_c.

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..... **[4]**

[Total: 10]

3 Hydrogen and iodine react together in a reversible reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9\,kJ\,mol^{-1}$$

A chemist mixes together 2.00×10^{-3} mol $H_2(g)$ and 4.00×10^{-3} mol $I_2(g)$ in a $1.00\,dm^3$ container.
The chemist seals the container.
The mixture is heated and left to reach equilibrium.

At equilibrium, the mixture contains 3.00×10^{-4} mol of H_2.

(a) Calculate the equilibrium constant, K_c, including units, if any, for this equilibrium.

Give your answer to **three** significant figures.

K_c = ... units ..... **[5]**

(b) The chemist repeats the experiment several times. In each experiment, the chemist makes one change.

(i) The chemist uses 3.00×10^{-3} mol $H_2(g)$ instead of 2.00×10^{-3} mol $H_2(g)$.

Predict whether the amounts of $H_2(g)$, $I_2(g)$ and $HI(g)$ in the equilibrium mixture would be greater, smaller or the same as in the original experiment.

Answer by placing ticks in the appropriate boxes of the table below.

	$H_2(g)$	$I_2(g)$	$HI(g)$
Greater			
Smaller			
The same			

[2]

(ii) The chemist heats the mixture to a higher temperature at constant pressure.

Explain whether the value of K_c would be greater, smaller or the same.

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..... **[1]**

(iii) The chemist increases the pressure of the mixture at constant temperature.

Explain whether the value of K_c would be greater, smaller or the same.

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[Total: 9]