

Australian Islamic College 2018

ATAR Chemistry Units 3 and 4

Task 1 (Weighting: 2%)

Equilibrium Test

Test Time: 45 minutes

Please do not turn this page until instructed to do so.

First Name	Surname
Answers	

Teacher

Mark / 45	Percentage

Equipment allowed: Pens, pencils, erasers, whiteout, rulers and non-programmable calculators permitted by the Schools Curriculum and Standards Authority.

Special condition: 2 marks will be deducted for failing to write your full name on this test paper.

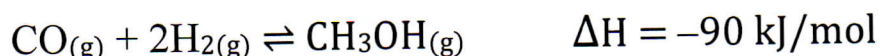
Teacher help: Your teacher can only help you during your test in one situation.

If you believe there is a mistake in a question show your teacher and your teacher will tell you whether or not there is a mistake in the question and if appropriate, how to fix that mistake.

Questions must be answered in this booklet, in the spaces provided.

Total marks: 45

1. Methanol is an important alcohol used in fuel mixtures. The following reaction is used for the industrial production of methanol (CH₃OH).



All parts of question 1 are about this reaction.

- (a) Would an increase in temperature increase, decrease or not change the value of K for this reaction? Justify your answer.

[2 marks]

Decrease ①

An increase in temperature favours the endothermic reaction, which is the reverse reaction, so the concentration of products will increase. ①

- (b) During this process the methanol is continuously removed by condensation to liquid. Explain the benefit of doing this with reference to Le Chatelier's Principle.

This will increase the yield/the production² of methanol ① because according to LCP [1 mark]

removal of a product will favour the forward reaction/result in the production of more product. ①

- (c) This reaction is at equilibrium in a closed system. Some hydrogen gas was removed from the system. State the response of the system after the stress has been applied on each of these.

[3 marks; 1 mark each]

- i. The concentration of carbon monoxide.

Increased ①

- ii. The concentration of hydrogen gas.

Increased ①

- iii. The concentration of methanol.

Decreased ①

(d) When methanol is produced industrially, a Cu-ZnO- Al_2O_3 catalyst is used. State the effect of the catalyst on

i. The position of the equilibrium

No change ①

[1 mark]

ii. The reaction rate

Increased ①

[1 mark]

(e) In practice methanol is synthesized at a temperature of 250°C and a pressure of $5-10 \times 10^6 \text{ Pa}$.

i. Explain why the choice of 250°C is a compromise between two factors.

[2 marks]

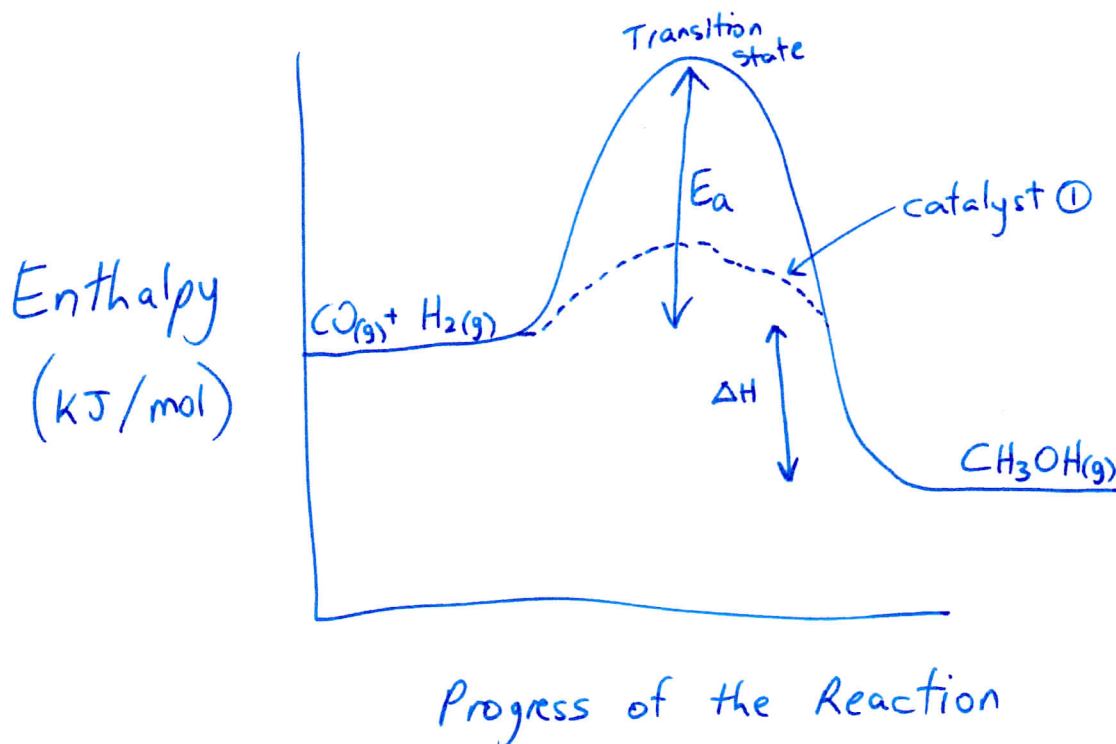
A low temperature increases yield by favouring the exothermic / forward reaction ①
but a high temperature increases reaction rate. ①

ii. Explain how the choice of a pressure of $5-10 \times 10^6 \text{ Pa}$ is also a compromise between two factors.

[2 marks]

A high pressure increases yield / pushes the reaction to the right / favours the formation of product ①
but high pressures are expensive / dangerous. ①

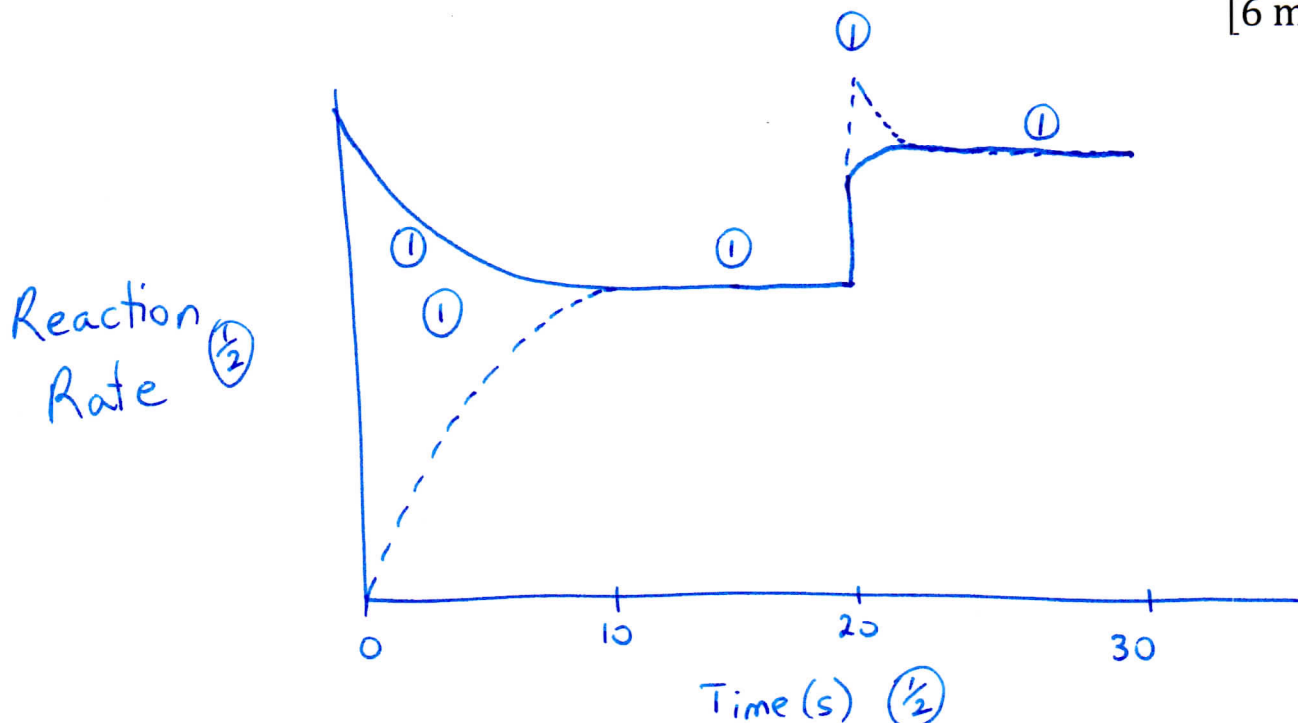
- (f) Draw an energy profile for the forward reaction for the synthesis of methanol. Label all parts of your diagram.
[5 marks; 1 mark off per missing item]



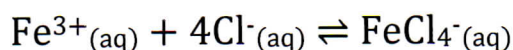
- (g) On the energy profile you drew for part (f) above, use a different colour (or a dashed line) to draw the energy profile for the same reaction in the presence of a catalyst. Label this appropriately.
[1 mark]

- (h) At time zero a sealed container contains only carbon monoxide and hydrogen. After 10 seconds the system has reached equilibrium. After 10 more seconds the system is heated. After another 10 seconds equilibrium is again attained. Sketch a graph of reaction rate against time for both the forward and the reverse reactions. Clearly draw the forward reaction with a solid line and the reverse reaction with a dashed line.

[6 marks]



2. The following equilibrium exists in a closed system.



At 298K $K_c = 8.0 \times 10^{-2}$.

Given that $[\text{Fe}^{3+}] = 0.2 \text{ mol L}^{-1}$ and $[\text{Cl}^{-}] = 0.80 \text{ mol L}^{-1}$, determine the concentration of FeCl_4^{-} .

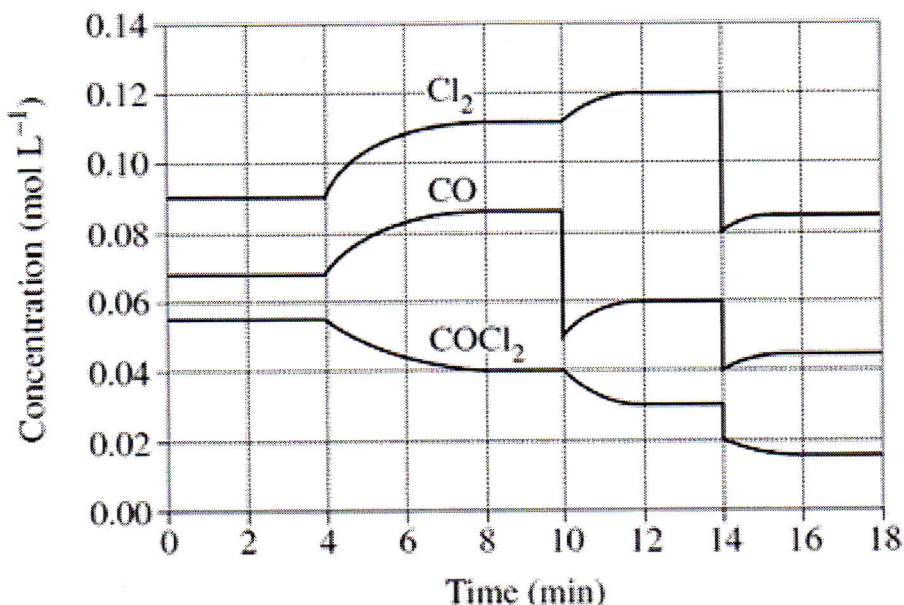
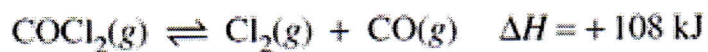
$$K_c = \frac{[\text{FeCl}_4^{-}]}{[\text{Fe}^{3+}][\text{Cl}^{-}]^4}$$

[2 marks]

$$[\text{FeCl}_4^{-}] = 8.0 \times 10^{-2} \times 0.2 \times [0.8]^4 = 0.007 \text{ mol L}^{-1}$$

no marks off
for wrong S.F.

3. The following equilibrium is present in a closed system.



Identify the change that occurred to the system at each of the following times.

[3 marks; 1 mark each]

(a) 4 minutes

Temperature increase

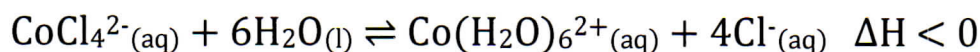
(b) 10 minutes

Removal of CO

(c) 14 minutes

Decrease in pressure / increase in volume.

4. The following equilibrium exists in a test tube. As all components of the system are aqueous or liquid, this is a reasonable approximation of a closed system.



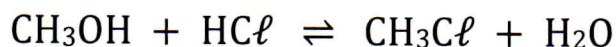
$\text{CoCl}_4^{2-}(\text{aq})$ is blue whereas $\text{Co}(\text{H}_2\text{O})_6^{2+}(\text{aq})$ is pink.

Complete this table describing the effect of various stresses to this equilibrium.

[7 marks; 1 mark off per mistake]

Stress on System	Colour Change (pink to blue; blue to pink or no change)	Equilibrium pushed to the left, to the right, or no change	Increase in K_c , decrease in K_c or no change
Addition of $\text{HCl}(\text{aq})$	<i>Pink to blue</i>	<i>Left</i>	<i>No change</i>
Heating of system	<i>Pink to blue</i>	<i>Left</i>	<i>Decrease</i>
Cooling of system	<i>Blue to pink</i>	<i>Right</i>	<i>Increase</i>
Addition of $\text{AgNO}_3(\text{aq})$	<i>Blue to pink</i>	<i>Right</i>	<i>No change</i>
Addition of a catalyst	<i>No change</i>	<i>No change</i>	<i>No change</i>

5. Chloromethane can be produced industrially by the reaction of methanol and hydrogen chloride at high temperature in the presence of a catalyst. The equation for this reaction is shown below.



The boiling points and melting points for each of the species involved in the reaction are shown below.

Species	Boiling point (°C)	Melting point (°C)
CH ₃ OH	65	-98
HCl	-85	-114
CH ₃ Cl	-24	-98
H ₂ O	100	0

Write the phase, i.e., solid (s), liquid (l) or gas (g), of each species in this system at the temperatures shown in the table below, and predict the effect of an increase in total pressure on this equilibrium at each of the temperatures.

[8 marks]

Temperature (°C)	Phase (s, l or g)				Shift in equilibrium (left, right or no change)
	CH ₃ OH	HCl	CH ₃ Cl	H ₂ O	
-50	l	g	l	s	Right ①
40	l	g	g	l	No change ①
70	g	g	g	l	Right ①
110	g	g	g	g	No change ①

For phases - 1 mark per correct row.

END OF TEST