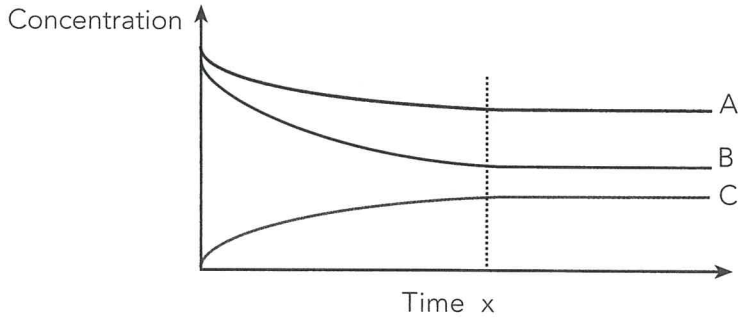
TRIAL TEST 1:
CHEMICAL EQUILIBRIUM

Time allowed:	70 minutes	Section 1 – Multiple Choice	20 marks
Total marks:	80	Section 2 – Short & Extended Answer	60 marks

SECTION 1 – MULTIPLE CHOICE (20 MARKS)

Section 1 – Multiple Choice (20 marks)

1. The graph below shows the change in concentration for gases present over a period of time for the reaction that occurs when sulfur dioxide is burnt in oxygen in a closed system.



REACTION: $2SO_2 + O_2 \rightarrow 2SO_3$, $\Delta H = -99$ kJ mol^{-1}.

Which of the following is correct?

(a) Line A represents the change in concentration for SO_3.
(b) Line B represents the change in concentration for SO_3.
(c) Time x represents the time when the concentration of SO_2 and SO_3 become equal.
(d) Time x represents the time when the forward reaction and the reverse reaction rates become equal.

2. For the reaction given in question 1,

(a) $K = \dfrac{[SO_2]^2.[O_2]}{[SO_3]}$

(b) The equilibrium yield of sulfur trioxide can be increased by raising the temperature of the system.
(c) The equilibrium yield of sulfur trioxide can be increased by raising the pressure in the reaction vessel.
(d) The rate of attainment of equilibrium can be increased by increasing the volume of the reaction vessel.

3. Which of the following reactions is endothermic?

(a) $CO_{2(s)} \rightarrow CO_{2(g)}$
(b) $Mg^{2+} + 2e^- \rightarrow Mg$
(c) $H + H \rightarrow H_2$
(d) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

4. When a catalyst is added to an exothermic reaction,
   (a) a new reaction pathway of lower activation energy is created.
   (b) the energy released, per mole of reactant, is increased.
   (c) the reaction mechanism alters to reduce the energy of the products.
   (d) more energy is absorbed from the surroundings and the reaction rate is increased.

5. Silver ions react with chloride ions and ammonia according to the following equations:

$$Ag^{+}(aq) + Cl^{-}(aq) \rightleftharpoons AgCl(s)$$
$$Ag^{+}(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^{+}(aq)$$

   If ammonia solution was added to a saturated solution of silver chloride,
   (a) there will be no change to the solubility of the AgCl as ammonia is less reactive than chlorine.
   (b) the NH_3 will increase the solubility of the AgCl by removing Ag^{+} ions from the solution.
   (c) as AgCl is not part of the process forming the complex ion, it solubility will not be affected.
   (d) the AgCl will become more soluble because the NH_3 is more polar than water.

6. The thermite process is summarised by the equation below:

$$2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(l) + Al_2O_3(s) + \text{energy}$$

   Which of the following statements is correct?

   (a) Adding HCl will increase the reaction rate by increasing the state of sub-division of the Al.
   (b) Grinding both reactants into a fine powder will increase the amount of Fe produced.
   (c) Removing the Fe as it is produced will increase the reaction rate.
   (d) Grinding the solids to powder will increase the rate at which the Al is consumed.

7. If the following reaction is carried out at a higher temperature the yield of HI(g) will be greater. Which of the following best explains the reason for this.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +52 \text{ kJ mol}^{-1}.$$

   (a) Increasing the temperature causes the forward reaction to increase.
   (b) Increasing the temperature causes a nett forward reaction because the reaction is endothermic.
   (c) Increasing the temperature causes the activation energy to be lowered and hence it is easier for products to form.
   (d) Increasing the temperature causes a greater number of collisions between reacting particles and hence more product is formed.

8. When developing black and white film in photography, sodium thiosulfate ($Na_2S_2O_3$) can be used to wash out any unexposed silver bromide salt.

$$AgBr(s) + 2S_2O_3^{2-}(aq) \rightarrow Ag(S_2O_3)_2^{3-}(aq) + Br^{-}(aq)$$

   The rate at which the thiosulfate ion ($S_2O_3^{2-}$) dissolves the silver bromide could be increased by:
   (a) adding more silver bromide to the solution.
   (b) removing bromide ions from the solution.
   (c) increasing the temperature of the solution.
   (d) increasing the pressure on the system.

9. A solution of potassium dichromate actually contains a mixture of chromate ions and dichromate ions in equilibrium (equation given below). The position of equilibrium being determined by the conditions present.

$$Cr_2O_7^{2-}(aq) + H_2O(l) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$$

orange solution *yellow solution*

Which of the following imposed changes would favour the formation of dichromate ions?

(a) The addition of more water to the system.
(b) The addition of a chemically selective catalyst.
(c) The addition of concentrated sodium hydroxide to the system.
(d) The addition of concentrated hydrochloric acid to the solution.

10. A sealed tube of the brown gas nitrogen dioxide actually contains a mixture of nitrogen dioxide and dinitrogen tetroxide. The equation for the equilibrium that exists between these two gases is:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) + 57\ kJ$$

Any change to this equilibrium system that favours the formation of $NO_2(g)$ causes the system to become a darker brown colour, while any change that favours the formation of $N_2O_4(g)$ causes the system to become a lighter brown colour.

Given the above information, which of the statements below is correct?

(a) Placing the tube in hot water would cause the gas mixture to become a lighter brown colour.
(b) Increasing the pressure would cause the system to become a lighter brown colour.
(c) Injecting a suitable catalyst would cause the system to become a lighter brown colour.
(d) Injecting more N_2O_4 into the cylinder would cause the system to become a lighter brown colour.

SECTION 2 – SHORT AND EXTENDED ANSWER (60 MARKS)

Answer each question in the space provided.

11. An important chemical reaction is the combustion of petrol in the cylinder of a motor of a vehicle.

$$2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(g)} + \text{Energy}$$

Use the collision theory to explain three ways by which the rate of this reaction could be increased.

(a)

(b)

(c)

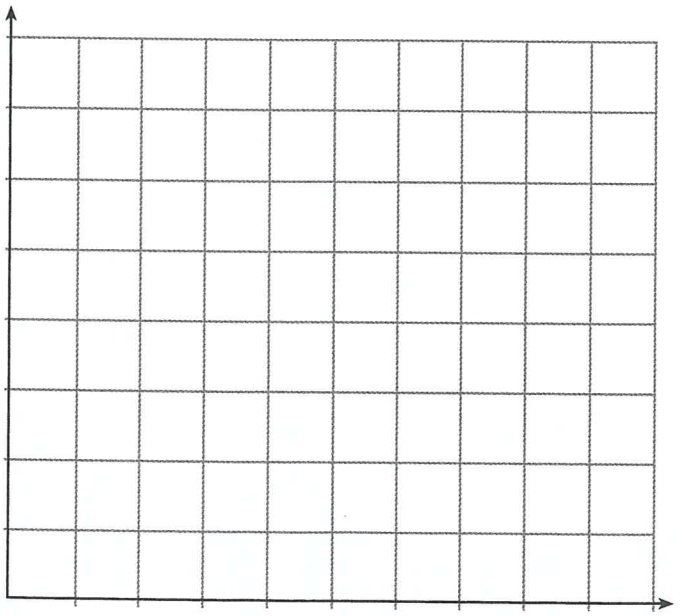
[6 marks]

12. Use the axes below to draw the energy profile diagram for the combustion of methane.

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$; $\Delta H = -890 \text{ kJ mol}^{-1}$, $E_a = 320 \text{ kJ mol}^{-1}$

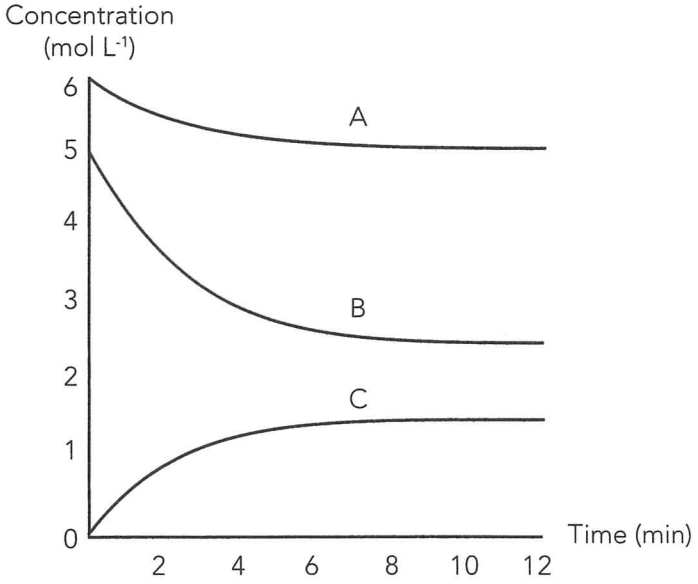
Include the following labels.

(a) enthalpy (b) reaction coordinates (c) ΔH
(d) activation energy (e) activated complex (f) reactants
(g) products (h) a catalysed reaction pathway.



[8 marks]

13. The gases nitrogen and hydrogen will react to form ammonia gas. In an experiment some hydrogen and nitrogen were placed in a flask and allowed to react. The concentrations of the gases present in the flask were monitored for a few minutes and the data graphed as shown below.



(a) Name the gases represented by lines B and C on the graph

Line B _____

Line C _____

(b) Write the equation for the reaction between the gases N_2, H_2 and NH_3.

_____

(c) Compare the forward and reverse reaction rates for this reaction at:

(i) t = 2 _____

(ii) t = 10 _____

(d) Some ammonia gas is removed from the container at t = 10. How will this initially effect the:

(i) forward reaction rate _____

(ii) reverse reaction rate _____

[8 marks]

14. Ammonia can be used to produce HNO_3 through a series of reactions culminating in the following step:

$$3NO_{2(g)} + H_2O_{(l)} \rightleftharpoons 2HNO_{3(aq)} + NO_{(g)}$$

(a) State what effect the following changes will have on the equilibrium yield of nitric acid (increase, decrease or no change) and explain why this occurs.

(i) Increasing the pressure on the system.

(ii) Removing NO_2 from the system.

(iii) Adding NO to the system.

(b) Write the expression for the equilibrium constant K for this system.

[8 marks]

15. In a closed system the reaction between $CaCO_3$ and 2 mol L^{-1} HCl will reach equilibrium and K will have a very large value.

$$CaCO_{3(s)} + 2H^+_{(aq)} \rightleftharpoons Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

State what effect the following changes will have on the position of equilibrium. Give a reason for your answer.

(a) Add another 10 mL of 2 mol L^{-1} HCl.

(b) Grind the $CaCO_3$ into smaller pieces.

(c) Add a large amount of H_2O to the system.

[6 marks]

16. When $BiCl_3$ is placed in water, the equation representing the equilibrium is:

$$\underset{\textit{colourless}}{BiCl_{3(aq)}} + Cl^-_{(aq)} + H_2O_{(l)} \rightleftharpoons \underset{\textit{white precipitate}}{BiOCl_{(s)}} + 2H^+_{(g)} + 3Cl^-_{(g)}$$

(a) State how the following changes alter the position of the equilibrium (to the right, to the left, unchanged) and give a probable observation.

(i) More powdered $BiOCl_{(s)}$ was added.

_____

(ii) Several drops of concentrated HCl were added.

_____

(iii) Several drops of concentrated sodium hydroxide solution.

_____

(b) Gentle warming caused the white solid to dissolve. Is the reaction, as represented by the equation above, exothermic or endothermic? Explain your prediction.

_____

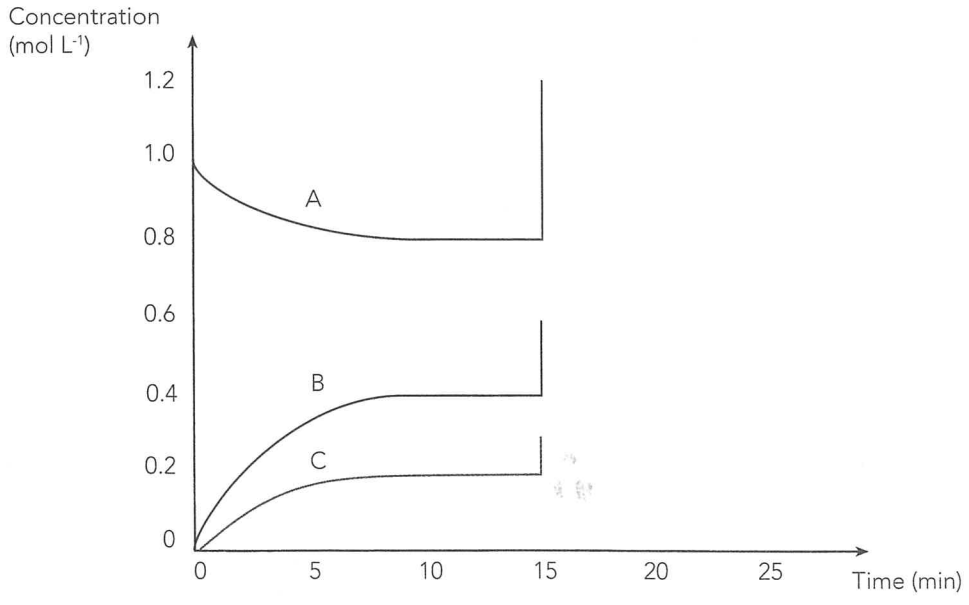
_____

_____

[8 marks]

17. Consider the following equilibrium reaction:

$$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$$



(a) What happened at t = 10 min?

_____

(b) Name the components of the reaction represented on the graph.

A _____, B _____, C _____

(c) Write an expression for the equilibrium constant for the reaction and calculate its value.

(d) What change was made to the system at t = 15 min?

(e) Complete the graph to show what is likely to happen after t = 15 min.

(f) Explain why the system is likely to behave in the way you have indicated and in particular why the concentration of each reactant changes in the way you have shown.

[16 marks]

END OF TEST (80 MARKS)

ANSWERS TO TRIAL TESTS

TRIAL TEST 1:
Reaction Rates and Equilibrium

Section 1

1. *d*
2. *c*
3. *a*
4. *a*
5. *b*
6. *d*
7. *b*
8. *c*
9. *d*
10. *b*

[20]

Section 2

11.

(a) Increase pressure - concentration of the O_2 is increased, this will increase the likelihood of a successful collision between reactant particles as there are more O_2 particles per unit volume.

(b) Increase the surface area of the C_8H_{18} - make it into a fine spray. Reactions occur on the surface of solids and liquids - by increasing the surface area the chance of a successful collision is increased.

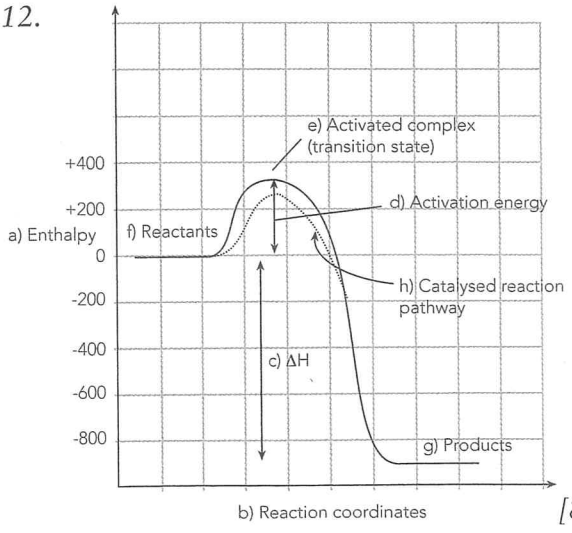
(c) Increase the temperature - reactant particles will be moving more rapidly - collisions will be more frequent and more energetic. The number of successful collisions occurring will increase.

or/and:

Add a Catalyst: an alternative reaction pathway exists that requires less energy – hence more of the collisions will now have an energy greater than the activation energy.

[6]

12.



[8]

13.

(a) Line B is H_2 while line C is NH_3

(b) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

(c) At t = 2 the forward reaction rate is greater than the reverse reaction rate. At t = 10 the forward and reverse reaction rates are equal.

(d) (i) Forward RR no change since no change to concentrations of the reactants.

(ii) Reverse RR will initially be lower as the concentration of the products is lower.

[8]

14.

*(a) (i) **increase,** since extra pressure favours the side with less gaseous molecules (there are 3 on the left and only 1 on the right)*

*(ii) **decrease,** the equilibrium position shifts to the left to partially counteract the imposed change*

*(iii) **decrease,** the equilibrium position shifts to the left to partially counteract the imposed change*

(b) $K = \dfrac{[HNO_3]^2[NO]}{[NO_2]^3}$

[8]

15.

(a) No change – the concentration of the H_2SO_4 has not been changed.

(b) No change – the concentration of the $CaCO_3$ is not altered.

(c) Reverse reaction favoured – concentrations decreased equally – reverse reaction favoured to partially counteract this.

[6]

16.

(a) (i) Unchanged – white powder will settle on the bottom.

(ii) To the left – white precipitate dissolves.

(iii) To the right – more white precipitate produced.

(b) Exothermic – on warming the reaction is favoured that tries to oppose this warming, ie. reaction that consumes energy is favoured which is the reverse reaction.

[8]

17.

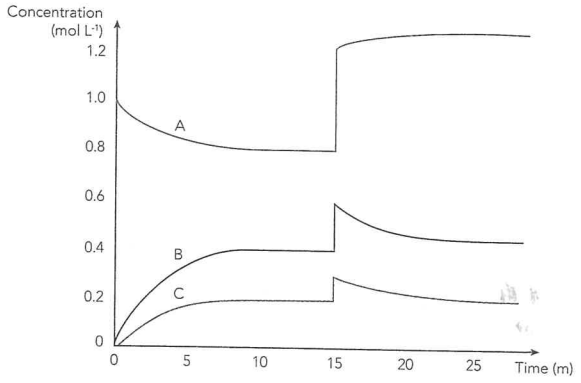
(a) Equilibrium was reached.

(b) A is CH_3OH, B is H_2, C is CO

(c) $K = \dfrac{[CH_3OH]}{[CO][H_2]^2} = \dfrac{(0.8)}{(0.2)(0.4)^2} = 2.5$

(d) *Pressure was increased by reducing volume of the containing vessel.*

(e)



(f) *The equilibrium will shift so as to compensate for the greater imposed pressure. Moves right as there are less molecules. Concentration of the H_2 affected most as there are two molecules of it. The other reactants affected equally (one molecule of each) but in opposite directions.*

[16]

TRIAL TEST 2:
Acids and Bases

Section 1

1. *d*	6. *d*
2. *b*	7. *a*
3. *a*	8. *b*
4. *c*	9. *b*
5. *c*	10. *d*

[20]

Section 2

11.

(a) *Test: Add $Ba(NO_3)_{2(aq)}$ to both solutions*
Observation: white precipitate forms in the H_2SO_4, no change in the HNO_3

(b) *Test: Add powders to HCl solutions*
Observation: $MgCO_3$ will fizz as bubbles of gas are produced, $Mg(OH)_2$ will simply dissolve

(c) *Test: Add universal indicator to both*
Observation: KCl solution will turn green, KCH_3COO will form orange/yellow.

[12]

12.

(a) $Ba^{2+}_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)} + 2H_2O_{(l)}$

(b) $3OH^-_{(aq)} + H_3PO_{4(aq)} \rightarrow PO_4^{3-}{}_{(aq)} + 3H_2O_{(l)}$

(c) $CaCO_{3(s)} + 2H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

[6]

13. *HCl is a strong acid and is completely ionized when in solution*

$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

For HCl, the $[H^+] = [HCl]$

CH_3COOH is a weak acid and so only a small percentage of molecules ionise

$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$

For CH_3COOH, the $[H^+] < [CH_3COOH]$
Therefore, $[H^+]$ in HCl is > $[H^+]$ in CH_3COOH and pH of 0.01 mol L^{-1} HCl is less

[4]

14. (a) $H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$

(b) $H_3PO_{4(aq)} \rightleftharpoons H^+_{(aq)} + H_2PO_4^-{}_{(aq)}$

(c) $H_2SO_{4(aq)} \rightleftharpoons H^+_{(aq)} + HSO_4^-{}_{(aq)}$

[6]

15.

(a) *Hydrolysis is the reaction between a salt and water to produce either H_3O^+ ions or OH^- ions.*

(b)

(i) $CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + OH^-_{(aq)}$; *basic*

(ii) $CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + OH_{(aq)}$; *basic*

(iii) $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+_{(aq)}$; *acidic*

[8]

16.

(a) *be obtained pure; have a known formula; not react with surroundings; have a high molar mass*

(b) *deliquescent: absorbs water from the atmosphere and dissolves in the water*

(c) *end point: the point at which the titration is stopped because the desired colour change is observed*
equivalence point: reactants have been mixed in stoichiometrically equivalent amounts

[8]

17.

(a) $H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

(b) *The OH^- ions will reduce the concentration of the H_3O^+ ions. The forward reaction would be favoured to partially counteract this change and the pH would remain reasonably constant.*

(c) *The buffer capacity of the solution would be exceeded and the pH would drop considerably.*

[6]

18. $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$
2 mol 1 mol
$M(Na_2CO_3)$ = 45.98 + 12.01 + 48.00 = 105.99