PERTH MODERN SCHOOL
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INDEPENDENT PUBLIC SCHOOL

YEAR 12 CHEMISTRY

TEST 1

Chemical Equilibrium Systems Answer Booklet

STUDENT NAME ______________________________

TEACHER ______________________________

Recommended time: 50 minutes

PLEASE:

- DO NOT TURN THE PAGE UNTIL INSTRUCTED

Section one:	20 Multiple choice	/20 marks
Section two:	3 Short answer questions	/15 marks
Section three:	1 Extended answer question	/10 marks

MULTI-CHOICE ANSWER SHEET

Use a blue or black biro to mark the correct answer by shading over the letter (eg. B)
If you change your mind, shade over the letter for the revised correct answer (as above) and place a cross through the deleted answer (eg.).

1	A	B	C	**D**
2	**A**	B	C	D
3	A	**B**	C	D
4	**A**	B	C	D
5	A	**B**	C	D
6	A	B	**C**	D
7	A	B	C	**D**
8	A	**B**	C	D
9	A	B	**C**	D
10	A	B	**C**	D
11	**A**	B	C	D
12	A	**B**	C	D
13	A	B	C	**D**
14	A	B	C	**D**
15	A	B	C	**D**
16	A	B	**C**	D
17	**A**	B	C	D
18	A	B	**C**	D
19	A	B	C	**D**
20	A	**B**	C	D

You may use the space for rough working for multi-choice questions

Section Two: Short Answer 15 marks

Answer these questions in the spaces in the answer booklet

21. Consider 500 mL of a solution in a 1.00 L beaker at 25 ºC and 100 kPa. The solution contains the following equilibrium mixture:

$$\underset{\text{(green)}}{CuC\ell_4^{\,2-}(aq)} \rightleftharpoons \underset{\text{(blue)}}{Cu(H_2O)_6^{\,2+}(aq)} + 4C\ell^-(aq)$$

When green and blue coloured solutions are mixed the colour of the solution is described as cyan, a colour halfway between **blue** and **green**. The forward reaction as written is exothermic.

If the initial equilibrium solution is cyan in colour complete the table below by describing the effect of the following changes made to the system

Imposed change	**Observation**
Increase the temperature to 95ºC	Cyan to green
Increase the pressure to 200 kPa	No change
Add concentrated HCℓ to the solution	Cyan to green
Add silver nitrate solution	White precipitate Solution turn blue or cyan to blue (need both)
Dilute the solution by adding 100 mL of water to the beaker.	Cyan to blue

(5 marks)

22. The following equilibrium is being investigated.

$$2\ ZnS\ (s) + 3\ O_2(g) \rightleftharpoons 2\ ZnO(s) + 2\ SO_2(g) \qquad \Delta H = -879\ kJ\ mol^{-1}$$

Three identical sealed reaction vessels are set up, each containing the equilibrium mixture. Each reaction vessel is treated as described as below, and time is allowed for a new equilibrium to be established. In each case describe the change between the original equilibrium and the new equilibrium.

Treatment	What happens to the rate of the forward reaction? Write “increases”, “decreases” or “no change”.	What happens to the position of equilibrium? Write “move to the right”, “ move to the left” or “no change”. Do not use → or ←
A small amount of O_2 (g) is added	Increase	Move to right
Powdered ZnS is injected into the reaction vessel.	Increase	No change
The reaction vessel is cooled.	Decrease	Move to the right

(6 marks)

23. Ammonia is able to react with itself, in a process known as "self-ionisation". The equation for the self-ionisation is below.

$$NH_3(aq) \quad + \quad NH_3(aq) \quad \rightleftharpoons \quad NH_4^+(aq) \quad + \quad NH_2^-(aq)$$

(a) Write the equilibrium constant expression for the self-ionisation of ammonia

$$K = \frac{[NH_4^+][NH_2^-]}{[NH_3]^2}$$

(1 marks)

(b) At standard temperature and pressure, the equilibrium constant, K, for this reaction is about 1×10^{-30}. The self-ionisation of ammonia is an endothermic process. Will the value of K be, less than or greater than 1×10^{-30} at a temperature greater than 0 ºC?
Explain your answer. (3 marks)

- Value of K will be greater
- Forward reaction is endothermic and is favoured by increasing the temperature
- Position of equilibrium shifts to the right increasing the concentration of products which increases the value of K

Section Three: Extended answer 10 marks

In order to obtain full marks for the extended response question in your answer you must use the names of the chemicals and the conditions used in the process.

24 The Haber process is a chemical process that enables the direct synthesis of ammonia from hydrogen and nitrogen. The initial process was developed by the German physical chemist Fritz Haber and later was translated into a large-scale process using a catalyst and high-pressure methods by Carl Bosch.

The equation for the process is given below.

$N_2(g)$ +	$3H_2(g)$	$\rightleftharpoons$	$2NH_3(g)$	$\Delta H = -92.4$ kJ moL^{-1}
nitrogen	hydrogen		ammonia	

Modern commercial industrial plants producing ammonia run the process under the following conditions

- Temperature 550 ºC
- Pressure 350 times atmospheric pressure
- Iron/iron oxide catalyst

Under these carefully conditions the process is economically feasible achieving a yield of between 30 – 40% at a satisfactory rate of production.

The conditions under which the process is carried out under are a compromise between achieving a high rate of reaction and maximising the yield of ammonia.

(a) Explain why the conditions of temperature and pressure that have been selected are a compromise between and economic yield and the rate of production of ammonia.

(6 marks)

(b) Many industrial processes, including the Haber process, employ catalyst in the process.
Explain the role of the iron/iron oxide catalyst in the Haber process.

(2 marks)

(c) In an industrial plant, would the system ever be allowed to reach equilibrium? Explain your answer.

(2 marks)

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Conditions

- Temperature 550 ºC
- Pressure 350 atm

TEMPERATURE

Reaction is exothermic and yield is favoured at low temperature forward reaction is endothermic (1 mark)

Rate of reaction is favoured by increasing temperature (1 mark)

Compromise between yield and rate

- Temperature is raised to 550 ºC in order to achieve an economic rate of production and a reasonable yield of ammonia. (1mark)

PRESSURE

Both the rate of reaction and yield are favoured by increasing the pressure (1 mark)

- If the pressure is increased the position of equilibrium shift to the right increasing the yield of ammonia (1 mark)

- The cost of producing equipment that runs at high pressure is expensive an economic compromise is reached and the plant operates at 350 atm (1 mark)

(b)

- The catalyst lowers the activation energy of both the forward and reverse reaction (1 mark)
  A diagram can be used but it must acknowledge the lowering of both Activation Energies.

- A catalyst allows the system to reach equilibrium sooner

  OR
- Allows system to run at lower temperature because of lower energy requirement

(c)

- In an industrial process conditions are manipulated so the position of equilibrium is always to the left. (favouring forward reaction) (1 mark)
- Keeping the position of equilibrium to left favours the production of products increasing the yield. (1 mark)