Answers
and
Marking Scheme

Chemistry

HSC Course • 2007

Industrial Chemistry + Chemical Monitoring & Management

Theory Test (Parts A & B)

Part A

Answers for Questions 1 – 15				
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 ○

1 Which of the following is NOT an industrial use of ammonia?

(A) production of explosives
(B) production of fertilisers
(C) production of petrol
(D) production of polymers

2 Which equation represents the industrial synthesis of ammonia?

(A) $N^{3+} + 3H^- \rightarrow NH_3$
(B) $NH_4OH \leftrightharpoons NH_3 + H_2O$
(C) $4NO + 6H_2O \leftrightharpoons 4NH_3 + 5O_2$
(D) $N_2 + 3H_2 \leftrightharpoons 2NH_3$

3 Sodium carbonate has many uses.
Which of the processes requires the use of sodium carbonate?

(i) pickling of steel
(ii) manufacture of superphosphate
(iii) glass making
(iv) making soaps and detergents

(A) (i), (ii) and (iii) only
(B) (i), (iii) and (iv) only
(C) (ii) and (iii) only
(D) (iii) and (iv) only

4 Cationic detergents are the main component of which types of products?

(A) fabric softeners and disinfectants
(B) laundry and dishwashing detergents
(C) personal hygiene
(D) pesticides and cosmetics

5 Why is the dilution of concentrated sulfuric acid very exothermic?

(A) The sulfuric acid is being decomposed.
(B) The sulfuric acid is being ionised.
(C) The sulfuric acid is being oxidised.
(D) The sulfuric acid is being reduced.

6 Most of the electricity in NSW is produced by coal–fired power plants. During the combustion of coal all of these reactions (A, B, C and D) occur.

Which reaction does not require monitoring?

(A) $C + O_2 \rightarrow CO_2$
(B) $2C + O_2 \rightarrow 2CO$
(C) $S + O_2 \rightarrow SO_2$
(D) $N_2 + 2O_2 \rightarrow 2NO_2$

7 Consider the following reaction…

$$2CO_{(g)} + O_{2(g)} \leftrightharpoons 2CO_2 \quad \Delta H = \text{exothermic}$$

How will the value of the equilibrium constant (K) for the reaction be affected by a twofold increase in the pressure in the system at constant temperature?

(A) The K value will increase.
(B) The K value will be halved.
(C) The K value will not be affected.
(D) The K value will double.

8 Why is a catalyst used in the Haber process?

(A) Lower reaction vessel temperatures can be used.
(B) Cheaper, less pure reactants can be used to lower production costs.
(C) Air pollution emissions are significantly cut.
(D) It slows down the exothermic reaction reducing the danger of thermal explosions.

9 Which of the following reactions shows sulfuric acid behaving as a dehydrating agent?

(A) $CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 + 5H_2O$
(B) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$
(C) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
(D) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

10 Which of the following is NOT essential for the Solvay process?

(A) ammonia
(B) brine
(C) calcium chloride
(D) limestone

11 Which of these analyses could be performed using AAS?

(A) Monitoring of acidic oxides emitted from an industrial smoke stack.
(B) Determining the pesticide level in imported fruit juice.
(C) Investigating lead concentrations in soil along major highways.
(D) Measuring the phosphate content of laundry detergents.

12 Which method describes the correct preparation of 1.8 mol L^{-1} H_2SO_4 from concentrated acid?

(A) Place 250 mL of demineralised water in a 250 mL volumetric flask, then add 25 mL of concentrated sulfuric acid.
(B) Place 25 mL of concentrated sulfuric acid in a 250 mL volumetric flask, then add demineralised water to the mark.
(C) Place 25 mL of demineralised water in a 250 mL volumetric flask, then add 25 mL of concentrated sulfuric acid. Mix carefully, then add demineralised water to the mark.
(D) Place 200 mL of demineralised water in a 250 mL volumetric flask, then add 25 mL of concentrated sulfuric acid. Mix carefully, then add demineralised water to the mark.

13 AAS has been an essential tool in the scientific understanding of the effects of trace elements. What is a trace element?

(A) A toxic element.
(B) An element used to track down another element in an analysis.
(C) An element found in very small concentrations in a sample.
(D) An element which decomposes and leaves behind a residue which can be detected.

14 A student performs a gravimetric analysis of a 1.00 gram sample of lawn fertiliser using a precipitation/filtration technique.

How could the student increase the reliability of the data collected?

(A) Use a more accurate balance.
(B) Repeat the analysis several times.
(C) Use a finer grade of filter paper.
(D) Use a larger sample size.

15 The table compares galvanic and electrolytic cells.
Which is choice is correct?

	Direction of electron flow		*Reaction at electrode*	
	galvanic	*electrolytic*	*galvanic*	*electrolytic*
(A)	anode to cathode	anode to cathode	oxidation at anode	reduction at cathode
(B)	anode to cathode	cathode to anode	reduction at anode	oxidation at cathode
(C)	cathode to anode	cathode to anode	oxidation at anode	reduction at cathode
(D)	cathode to anode	anode to cathode	reduction at anode	oxidation at cathode

Part B

1 Evaluate the cleaning action of soap in soft and hard water. **(3 marks)**

*Possible answer***:**

Soaps have both polar (hydrophilic) and non-polar (hydrophobic) parts. The hydrocarbon part of soap interacts with the non-polar grease possibly dissolving the grease or dissolving in grease. The polar part of soap in turn can interact with water. This two fold interaction allows the soap to act as a bridge between grease and water, allowing it to act as an emulsifying agent, hence enabling it to wash away the grease in soft water. (2 marks)

In hard water, the efficiency of soap is reduced because of the ability of calcium and magnesium ions to precipitate soap. More soap is required to maintain the same cleaning. (1 mark)

Criteria	***Marks***
Description of the structure of soaps	*1*
Description of the cleaning action of soap	*1*
Evaluation of the efficiency of soap in hard water	*1*

2 The Frasch process is a widely used method to extract sulfur from deposits.

Analyse potential environmental issues assocated with the Frasch process. **(2 marks)**

Possible Answers (any two issues):

- ***possible emission of sulfur dioxide or hydrogen sulfide to the atmosphere due to the use of relatively elevated temperature which oxidise or reduce sulfur***
- ***earth subsidence can occur as a result of the process where materials are extracted from underground level***
- ***if the water is channeled back to a water body, there is the possibility of thermal pollution***

3 Given the reaction… $A + 2B \leftrightharpoons 2C$

When 1.00 mol of *A* and 1.50 mol of *B* are placed in a 2.00 L vessel and allowed to come to equilibrium, the equilibrium concentration of *C* was found to be 0.35 mol L^{-1}.

Calculate the equilibrium constant, *K* for the reaction showing all your working. **(4 marks)**

Possible solution:

		initial	*produced*	*used up*	*equilibrium*
1	*moles A*	1.00		0.35	0.65
2	*moles B*	1.50		0.70	0.80
3	*moles C*	0.00	0.70		0.70
4	*equilibrium [A]*				0.325
5	*equilibrium [B]*				0.40
6	*equilibrium [C]*				0.35

equilibrium moles of A, B and C ***(1 mark)***

equlibrium concentration of A, B, and C ***(1 mark)***

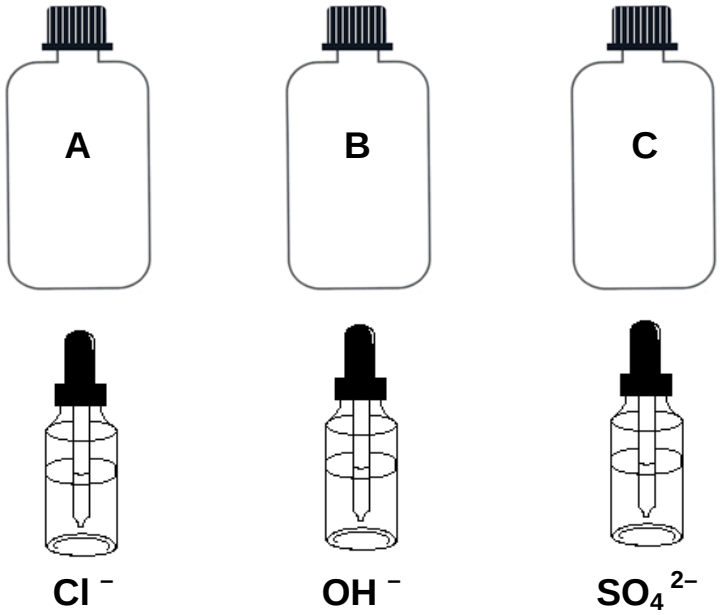
$K = \dfrac{[C]^2}{[A][B]^2}$ ***(1 mark)***

Substituting into the equilibrium constant expression

$K = \dfrac{(0.35)^2}{(0.325)(0.40)^2} = 2.4$ ***(1 mark)***

4 Boris sits for a qualitative analysis prac test. He was given three sample bottles (labelled A, B and C) and three dropper bottles (labelled Cl^-, OH^- and SO_4^{2-}).

The sample bottles were known to contain either Ba^{2+} or Cu^{2+} or Fe^{3+}.



Boris methodically tested the samples and recorded this table of results.
► *P = precipitate; NP = no precipitate*

	Cl^-	OH^-	SO_4^{2-}	Conclusion
A	P	P	P	
B	NP	P	NP	
C	NP	NP	P	

(a) Identify samples A, B, C by filling in the correct metal cation in the conclusion column above. **(2 marks)**

$$A = Pb^{2+} \quad B = Cu^{2+} \quad C = Ba^{2+}$$

(b) Write the net ionic equation for the chloride precipitate formed by A. **(1 mark)**

$$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2\,(s)}$$

(c) B can also be detected a by flame test. Identify the characteristic colour of the flame. **(1 mark)**

Green/blue

5 Analyse the conditions necessary for the efficient industrial production of ammonia. **(6 marks)**

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \quad \Delta H = -46\ kJ\ mol^{-1}$$

Pressure *– According to Le Chatelier's Principle, higher pressures (1 mark) would shift the equilibrium reaction to the right (the side with the least gas volume), thus favouring the production of ammonia. (1 mark) A high pressure of ≈ 200 atm is cost effective and safe.*

Temperature *– According to Le Chatelier's Principle, lower temperatures (1 mark) would shift the equilibrium to the right, the exothermic reaction (1 mark), thus favouring the production of ammonia. A temperature of ≈ 450°C is selected as a compromise between yield and rate.*

Catalyst *– A catalyst counteracts the effect of a slower rate due to the lowered temperature used in the Haber Process.) Fe_3O_4 is used as a catalyst to speed–up the reaction (or the achievement of equilibrium)(1 mark). A catalyst works by lowering the activation energy (1 mark).*

6 A university chemistry honours student is involved in a research project to analyse the concentration of mercury in canned tuna. The student extracts a very small, accurately weighed sample of flesh from a tin of tuna and 'digests' it by heating in excess concentrated nitric acid. This procedure converts any mercury present into soluble $Hg^{2+}_{(aq)}$. The treated sample was then transferred to a volumetric flask and water was added to prepare a 1000 mL solution.

An AAS instrument was then fitted with a hollow cathode mercury lamp and its alignment was adjusted to specifications. The prepared tuna mercury sample was then aspirated into the spectroscope's flame and the absorbance value was recorded at the correct wavelength.

Describe what further procedural steps the student must undertake in conjunction with the AAS instrument to determine the mercury concentration in the tuna sample. **(3 marks)**

(1) The student must prepare a series of standardised mercury solutions. (1 mark)

(2) These solutions are then individually run through the AAS and their absorbances recorded and a calibration curve is plotted. (1 mark)

(3) The value of the tuna sample's mercury concentration is determined by interpolation. (1 mark)