Trial Examination 2010

VCE Chemistry Unit 2

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

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

Question 1 D

A pH of 3 means that $[H^+] = 10^{-pH} = 10^{-3}$ M and so **A** is correct. As soap has a pH of 10 at 25°C, then $[H^+] = 10^{-10}$ M and $[OH^-] = 10^{-4}$ M. Alternative **B** is also correct. Milk has $[H^+] = 10^{-6}$ M whereas in bleach, $[H^+] = 10^{-12}$ M. Thus $[H^+]$ is $\frac{10^{-6}}{10^{-12}}$ times greater in milk than bleach, so **C** is correct. The hydrogen ion concentration is 10^{-7} M only at 25°C but will change with temperature. Alternative **D** is incorrect and is the required response.

Question 2 A

At high temperatures, the gas particles have higher kinetic energy, and energy losses due to collisions are negligible, producing the 'elastic' collisions of the ideal gas. At low pressures, distances between the gas particles are much larger and so the interactive forces between the particles are negligible. This approaches ideal gas particle behaviour.

Question 3 D

Nitrogen fixation involves bonding atmospheric nitrogen atoms to other elements. The formation of nitrogen(II) oxide, ammonium ions and nitrogenous fertilisers are all examples of this process (I, II and IV). Releasing nitrogen from compounds into the air, denitrification (III), is the opposite of nitrogen fixation. Thus **D** is the correct answer.

Question 4 C

The relevant half-equations are

$X(s) \rightarrow X^{2+}(aq) + 2e^-$ (oxidation)

$Y^{2+}(aq) + 2e^- \rightarrow Y(s)$ (reduction)

In a spontaneous redox reaction the stronger oxidant will be reduced by the stronger reductant. Thus Y^{2+} is a stronger oxidant than X^{2+}, and so alternative **A** is incorrect. X is a stronger reductant than Y, and so alternative **B** is incorrect. The Cl^- ion does not react here, and so alternative **D** is incorrect.

Question 5 B

Photochemical smog is smog in which reactions initiated by sunlight are taking place. It occurs on warm days when the air is still, as happens when there is a temperature inversion. The reactants involved in the series of steps leading to photochemical smog include unburnt hydrocarbons, nitrogen oxides and oxygen. Ozone is formed during the series of reactions, as are larger compounds such as peroxyacetylnitrate (PAN).

Question 6 A

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

$$\therefore \frac{720 \times 48}{(273 + 15)} = \frac{p_2 \times 24}{(273 + 30)}$$

$$\therefore p_2 = 1515 \text{ mmHg}$$

$$= \frac{1515}{760} \times 101.3 = 202 \text{ kPa}$$

Question 7 **D**

Graphs **A** and **C** show Boyle's law, the inverse relationship between volume and pressure. Graph **B** shows the direct relationship between pressure and amount of gas. Graph **D** shows that volume increases with increasing temperature, but incorrectly shows a zero gas volume at a temperature of 0°C, not 0 K, absolute zero. Graph **D** does not represent the behaviour of an ideal gas, and so is the required response.

Question 8 **C**

Oxygen and nitrogen gases consist of small non-polar molecules and have very low solubility at any temperature according to the table. Alternative **A** is a reasonable conclusion. Alternative **B** is clearly supported from the data. As the solubility of oxygen decreases with increasing temperature, it is to be expected that dissolved oxygen will come out of solution when the water is boiled and be seen as bubbles. Thus **D** is also reasonable. The solubility of sulfur dioxide depends largely on the polarity of its molecules, enabling dipole-dipole bonding with water molecules, and its reaction with water to form sulfurous acid. Its solubility is not due 'only' to its higher molar mass. Alternative **C** is not reasonable, and so is the required response.

Question 9 **C**

Sulfur dioxide and carbon dioxide contribute to making rainwater acidic and thus both gases produce acidic solutions when dissolved in water.

Question 10 **D**

$[H^+] = [HNO_3] = c \times V = 0.3 \times 10.0 \times 10^{-3} = 3.0 \times 10^{-3}$ M

$[H^+]$ for H_2SO_4 is between 3.0×10^{-3} M and 6.0×10^{-3} M, depending on the degree of ionisation of the second proton.

$[H^+] = [HCl] = c \times V = 0.1 \times 30.0 \times 10^{-3} = 3.0 \times 10^{-3}$ M

$[H^+] < [CH_3COOH] = c \times V = 0.1 \times 30.0 \times 10^{-3} = 3.0 \times 10^{-3}$ M due to the partial ionisation of the weak acid.

Question 11 **D**

Iron is the reductant, losing electrons during the reaction. Alternative **D** is correct. Oxygen is the oxidant and causes oxidation. Alternative **B** is incorrect. Hydrogen atoms in the reaction neither lose nor gain electrons, so alternatives **A** and **C** are incorrect. (The oxidation number of hydrogen does not change, whereas that of iron changes from 0 to +2, indicating that it is oxidised. Oxygen is reduced as its oxidation number changes from 0 to –2.)

Question 12 **A**

As all sodium salts are soluble it would not be possible to precipitate the sodium ions from sea water in order to desalinate a sample. The techniques listed in **B**, **C** and **D** are all able to be used for desalination, although the use of ion-exchange resins is usually limited to small scale desalination.

Question 13 **B**

Alternative **A** will introduce a more concentrated salt solution into the sea than the sea water which animals and plants inhabit. Disruption to the local habitat is likely. Generation of electricity produces gases which contribute to acid rain and the enhanced greenhouse effect. Thus **C** will impact the environment significantly. Construction work (alternative **D**) will permanently disrupt areas of the environment in a significant way. As dams are already constructed and many are depleted of water, topping up the water will have minimal impact on the environment. **B** is the required response.

Question 14 C

As HNO_3 is a strong acid, it ionises completely.

$n(H^+) = c \times V = 0.15 \times 0.0010$ mol

When diluted,

$$c(H^+) = \frac{n}{V} = 0.15 \times \frac{0.001}{0.150} = 0.0010 \text{ M}$$

$$\text{pH} = -\log[H^+] = -\log(0.0010) = 3$$

Question 15 B

In reaction I, H^-(aq) gains a H^+ to become H_2(g) and is thus a base. In reaction II, NH_3(g) loses a proton to become NH_2^-(aq) and therefore acts as an acid. In reaction III, H_2SO_4(aq) acts as an oxidant to oxidise the zinc atoms to zinc ions. It is a redox reaction. No transfer of protons occurs, and so it is not an acid-base reaction. Only in reaction II is the first reactant behaving as an acid and thus **B** is the required response.

Question 16 B

$$3P : 2Q : 5R$$

$$\therefore x : 1.50 : y$$

$$\therefore x = \frac{1.50}{2} \times 3 = 2.25 \text{ and } y = \frac{1.50}{2} \times 5 = 3.75$$

We require only 3.00 mol of R.

$$3P : 2Q : 5R$$

$$\therefore x : z : 3.00$$

$$\therefore x = \frac{3.00}{5} \times 3 = 1.80 \text{ mol and } z = \frac{3.00}{5} \times 2 = 1.20 \text{ mol}$$

To produce 3.00 mol of R we require 1.80 mol of P to react with 1.20 mol of Q.

Question 17 A

As H_2SO_4 produces two H^+ ions per molecule when reacted completely with NaOH, the number of mole of NaOH (and hence the volume) required for neutralisation would be twice that for HCl of the same concentration and volume. HCOOH is a monoprotic acid and will require the same amount of NaOH as HCl for neutralisation. Even though HCOOH is a weak acid, it will completely react with the strong base NaOH. The correct answer is **A**.

Question 18 A

In cell number 1 electrons flow away from electrode X (negatively charged) to electrode Z (positively charged). The relevant half-equations are

$X(s) \rightarrow X^{2+}(aq) + 2e^-$ (oxidation)

$Z^{2+}(aq) + 2e^- \rightarrow Z(s)$ (reduction)

Electrode Z is the site of reduction, the cathode.

Question 19 C

Oxidation occurs at the negatively charged electrode, hence alternatives **A** and **B** are incorrect.
From cell number 1, Z^{2+} is a stronger oxidant than X^{2+} (with a difference of 0.31 V).
From cell number 2, Z^{2+} is a stronger oxidant than Y^{2+} (with a difference of only 0.10 V).
Therefore Y^{2+} is a stronger oxidant than X^{2+}, and so X is a stronger reductant than Y.
The stronger reductant will undergo oxidation at the negatively charged anode, hence alternative **C** is correct.

Question 20 B

Metal Y has a reductant strength between that of Z (lead) and X (iron). From the electrochemical series in the Data Booklet, nickel fits these requirements, and so could possibly be metal Y.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. $n(H_2) = \frac{m}{M} = \frac{5.25}{2.0} = 2.63$ mol — 1 mark

$V(H_2) = n \times V_M = \frac{5.25}{2.0} \times 22.4 = 58.8$ L — 1 mark

b. **i.** Total $n(\text{gas}) = n(H_2) + n(O_2) = 2.63 + 0.301 = 2.93$ mol — 1 mark

$p = \frac{nRT}{V} = \frac{2.93 \times 8.31 \times (250 + 273)}{25} = 509$ kPa — 1 mark

ii. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ — 1 mark

iii. From the equation $n(H_2) : n(O_2) = 2 : 1 = 0.602 : 0.301$

Therefore H_2 is in excess by $2.63 - 0.602 = 2.028$ mol — 1 mark

$n(H_2O) = 2 \times n(O_2) = 2 \times 0.301 = 0.602$ mol — 1 mark

Total $n(\text{gas})$ remaining $= n(\text{excess } H_2) + n(H_2O) = 2.028 + 0.602 = 2.63$ mol — 1 mark

c. As the mixture is cooled, the gas molecules lose energy and their kinetic energy is decreased. — 1 mark
The gas molecules now strike the walls of the container less often and with less force, hence pressure decreases. — 1 mark

Total 10 marks

Question 2

a. Water is a covalent, molecular compound, which produces ions of very low concentration due to its self-ionisation reaction. With very few ions, the electrical conductivity is very low. — 1 mark

b. HCl is a strong acid that ionises fully in water and so will conduct electricity well. — 1 mark

CH_3COOH is a weak acid, which only partially ionises in water, producing a low concentration of ions and thus low electrical conductivity. — 1 mark

c. At pH = 11.6, $[H^+] = 10^{-11.6}$ M — 1 mark

At 25°C, $[H^+] \times [OH^-] = 10^{-14}$ M^2

$[OH^-] = \frac{10^{-14}}{10^{-11.6}} = 10^{-2.4} = 3.98 \times 10^{-3}$ M — 1 mark

In 250 mL, $n(OH^-) = c \times V = 3.98 \times 10^{-3} \times 250 \times 10^{-3} = 9.95 \times 10^{-4}$ mol — 1 mark

d. $H_2PO_4^-(aq) + HCl(aq) \rightarrow H_3PO_4(aq) + Cl^-(aq)$ — 1 mark

$H_2PO_4^-(aq) + OH^-(aq) \rightarrow HPO_4^{2-}(aq) + H_2O(l)$ — 1 mark

e. **i.** $n(HCl) = c \times V = 10 \times 0.075 = 0.75$ mol — 1 mark

$n(NaHCO_3) = n(HCl) = 0.75$ mol — 1 mark

$m(NaHCO_3) = n \times M = 0.75 \times 84 = 63$ g — 1 mark

ii. $NaHCO_3$ is relatively harmless and so an excess could be used to neutralise the acid. NaOH pellets could not be used in excess because any unused pellets would also pose a hazard and could cause serious burns. — 1 mark

Total 12 marks

Question 3

a. **i.** $m(\text{Pb(NO}_3)_2) = n \times M = 0.136 \times 331.2 = 45.0$ g — 1 mark

45.0 g of $\text{Pb(NO}_3)_2$ in 60 g of water

$\therefore$ x g of $(\text{Pb(NO}_3)_2$ in 100 g of water

$\therefore$ $x = 75$ g. This requires a temperature of 42°C (*note: accept 40–43*). — 1 mark

ii. 45.0 g in 60.0 mL of water (assuming the density of the water is 1.0 g mL^{-1}), therefore 75.0 g in 100 mL, i.e. 75% m/v. — 1 mark

b. $\text{Pb}^{2+}(aq) + \text{SO}_4^{\ 2-}(aq) \rightarrow \text{PbSO}_4(s)$ — 1 mark

c. **i.** $n(\text{Na}_2\text{SO}_4) = \frac{m}{M} = \frac{17.5}{142.1} = 0.123$ mol — 1 mark

Sodium sulfate is the limiting reagent in the precipitation reaction. The student has incorrectly used the amount of lead(II) nitrate in the calculation. — 1 mark

ii. The precipitate was not completely dried. The mass of the water added to the mass of the lead(II) sulfate precipitate. — 1 mark

Total 7 marks

Question 4

a. The reaction involves a transfer of electrons from the magnesium to the water. Thus water acts as an oxidant. — 1 mark

There is no transfer of protons and so water is acting as neither an acid nor a base in this reaction. — 1 mark

b. A blue solution forms, and a deposit occurs on the surface of the copper. — 1 mark

$\text{Cu}(s) + 2\text{Ag}^{+}(aq) \rightarrow \text{Cu}^{2+}(aq) + 2\text{Ag}(s)$ — 1 mark

Total 4 marks

Question 5

a. Distillation involves the separation of liquids of different boiling points by heating to effect evaporation. — 1 mark

The vapours are removed separately and cooled to cause condensation. The separate liquids are collected. — 1 mark

b. On freezing, water expands and can cause pipes to split open. — 1 mark

In ice, a water molecule is held in an open structure by hydrogen bonds to four other water molecules.This occupies a greater volume than the same mass of liquid water. — 1 mark

c. neon and helium — 1 mark

Note: These gases have much lower boiling points than –200°C and will remain as gases.

d. krypton — 1 mark

Note: The highest boiling point gas is collected at E*, the lowest boiling point gas at* A.

e. Carbon dioxide or oxygen are the most likely choices.

Gas	Method	Chemical equation	Collection
Carbon dioxide	Reaction of an acid with marble chips	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$	Upward displacement of air
Oxygen	Decomposition of hydrogen peroxide using MnO_2 catalyst	$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$	Downward displacement of water

1 + 1 + 1 = 3 marks
Total 9 marks

Question 6

a. CFCs are associated with the destruction of the ozone layer. 1 mark

CFCs are one of the gases responsible for the enhanced greenhouse effect. 1 mark

b. The sCO_2 must be produced from carbon dioxide, which has already been released by another process. 1 mark

c. Corn starch is produced from a renewable source.

OR

The product is biodegradable and will not accumulate in the environment.

1 mark

d. For example:
The design of a new reaction sequence for the production of ibuprofen to improve atom economy. 1 mark

This leads to less use of chemicals and energy. 1 mark

1 mark for description of an appropriate application using green chemical principles
1 mark for description of how the application satisfies green chemical principles

e. **i.** $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ 1 mark

(or any other chemical reaction of a human activity releasing carbon dioxide)

ii. $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ 1 mark

(or any other chemical reaction of a natural process removing carbon dioxide)

Total 8 marks