Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 2

Thursday 11 May 2017 (afternoon)

Candidate session number

1 hour 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

2217 – 6117

13 pages

Answer **all** questions. Write your answers in the boxes provided.

1. There are many oxides of silver with the formula Ag_xO_y. All of them decompose into their elements when heated strongly.

(a) (i) After heating 3.760 g of a silver oxide 3.275 g of silver remained. Determine the empirical formula of Ag_xO_y. [2]

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(ii) Suggest why the final mass of solid obtained by heating 3.760 g of Ag_xO_y may be greater than 3.275 g giving one design improvement for your proposed suggestion. Ignore any possible errors in the weighing procedure. [2]

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(b) Naturally occurring silver is composed of two stable isotopes, ^{107}Ag and ^{109}Ag.

The relative atomic mass of silver is 107.87. Show that isotope ^{107}Ag is more abundant. [1]

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(Question 1 continued)

(c) (i) Some oxides of period 3, such as Na_2O and P_4O_{10}, react with water. A spatula measure of each oxide was added to a separate 100 cm^3 flask containing distilled water and a few drops of bromothymol blue indicator.
The indicator is listed in section 22 of the data booklet.

Deduce the colour of the resulting solution and the chemical formula of the product formed after reaction with water for each oxide. [3]

Flask containing	Colour of solution	Product formula
Na_2O	. . . . .	. . . . .
P_4O_{10}	. . . . .	. . . . .

(ii) Explain the electrical conductivity of molten Na_2O and P_4O_{10}. [2]

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(d) Outline the model of electron configuration deduced from the hydrogen line emission spectrum (Bohr's model). [2]

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2. An acidic sample of a waste solution containing $Sn^{2+}(aq)$ reacted completely with $K_2Cr_2O_7$ solution to form $Sn^{4+}(aq)$.

(a) (i) State the oxidation half-equation. [1]

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(ii) Deduce the overall redox equation for the reaction between acidic $Sn^{2+}(aq)$ and $Cr_2O_7^{2-}(aq)$, using section 24 of the data booklet. [1]

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(b) (i) Calculate the percentage uncertainty for the mass of $K_2Cr_2O_7(s)$ from the given data. [1]

Mass of weigh boat / g ±0.001 g	1.090
Mass of weigh boat + $K_2Cr_2O_7(s)$ / g ±0.001 g	14.329

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(ii) The sample of $K_2Cr_2O_7(s)$ in (i) was dissolved in distilled water to form 0.100 dm^3 solution. Calculate its molar concentration. [1]

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(Question 2 continued)

(iii) $10.0\,cm^3$ of the waste sample required $13.24\,cm^3$ of the $K_2Cr_2O_7$ solution. Calculate the molar concentration of $Sn^{2+}(aq)$ in the waste sample. [2]

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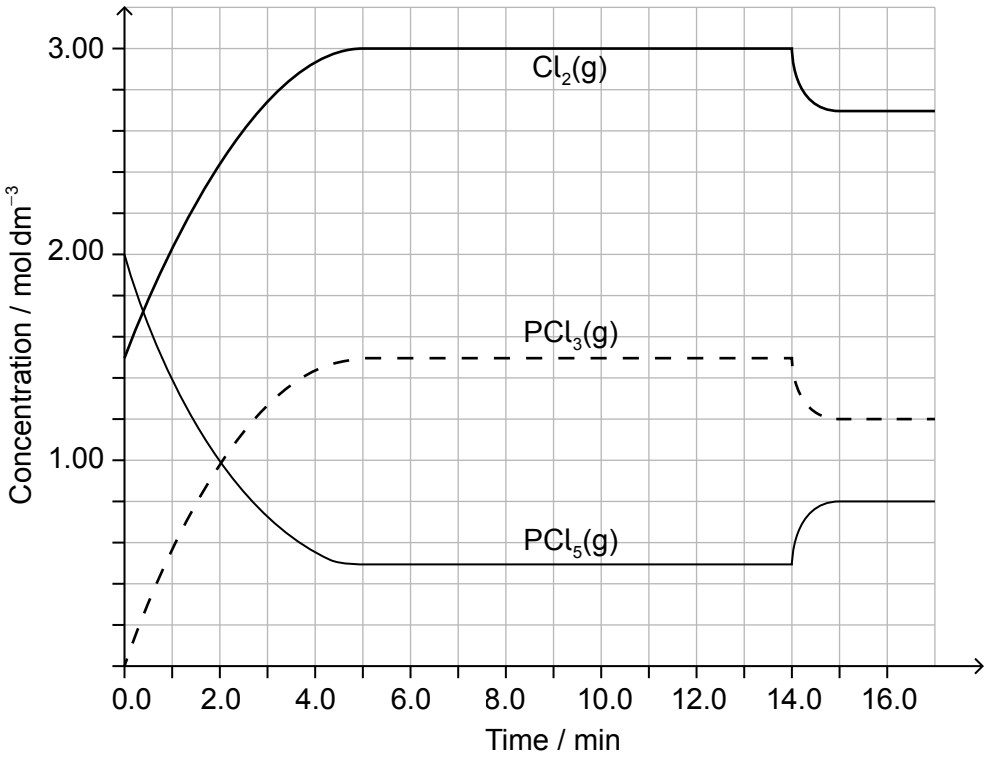
3. $PCl_5(g)$ and $Cl_2(g)$ were placed in a sealed flask and allowed to reach equilibrium at 200°C. The enthalpy change, ΔH, for the decomposition of $PCl_5(g)$ is positive.



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(a) (i) Deduce the equilibrium constant expression, K_c, for the decomposition of $PCl_5(g)$. [1]

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(Question 3 continued)

(ii) Deduce, giving a reason, the factor responsible for establishing the new equilibrium after 14 minutes. [2]

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(b) Deduce the Lewis (electron dot) structure and molecular geometry of PCl_3. [2]

Lewis structure:

Molecular geometry:

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4. Bonds can be formed in many ways.

(a) The landing module for the Apollo mission used rocket fuel made from a mixture of hydrazine, N_2H_4, and dinitrogen tetraoxide, N_2O_4.

$$2N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(g)$$

(i) State and explain the difference in bond strength between the nitrogen atoms in a hydrazine and nitrogen molecule. [2]

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(Question 4 continued)

(ii) State why hydrazine has a higher boiling point than dinitrogen tetraoxide. [1]

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(iii) Determine the oxidation state of nitrogen in the two reactants. [1]

N_2H_4:
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N_2O_4:
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(iv) Deduce, giving a reason, which species is the reducing agent. [1]

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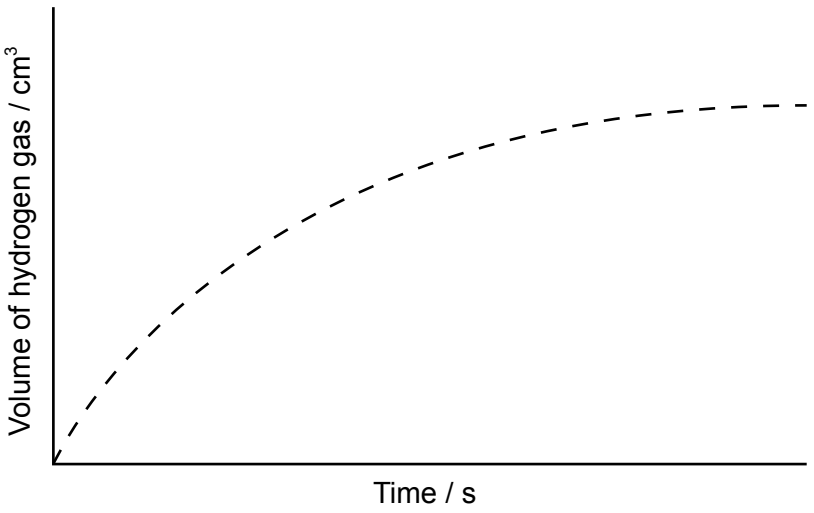
(b) Deduce the Lewis (electron dot) structures of ozone. [2]

5. (a) Magnesium reacts with sulfuric acid:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

The graph shows the results of an experiment using excess magnesium ribbon and dilute sulfuric acid.



(i) Outline why the rate of the reaction decreases with time. [1]

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(ii) Sketch, on the same graph, the expected results if the experiment were repeated using powdered magnesium, keeping its mass and all other variables unchanged. [1]

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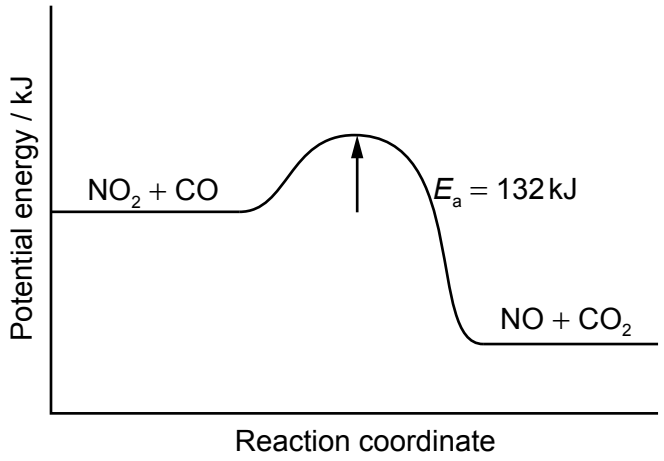
(Question 5 continued)

(b) Nitrogen dioxide and carbon monoxide react according to the following equation:

$$NO_2(g) + CO(g) \rightleftharpoons NO(g) + CO_2(g) \qquad \Delta H = -226\,kJ$$



Calculate the activation energy for the reverse reaction. [1]

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(c) State the equation for the reaction of NO_2 in the atmosphere to produce acid deposition. [1]

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6. The photochemical chlorination of methane can occur at low temperature.

(a) Using relevant equations, show the initiation and the propagation steps for this reaction. [3]

Initiation:

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Propagation:

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(b) Bromine was added to hexane, hex-1-ene and benzene. Identify the compound(s) which will react with bromine in a well-lit laboratory. [1]

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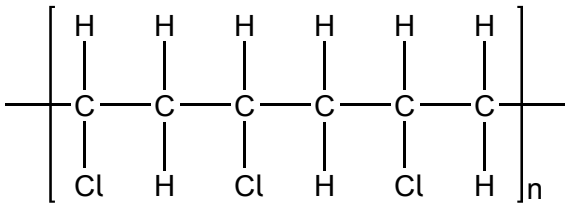
(c) Polyvinyl chloride (PVC) is a polymer with the following structure.



State the structural formula for the monomer of PVC. [1]

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7. Soluble acids and bases ionize in water.

(a) Sodium hypochlorite ionizes in water.

$$OCl^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + HOCl(aq)$$

(i) Identify the amphiprotic species. [1]

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(ii) Identify one conjugate acid-base pair in the reaction. [1]

Acid	Base
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(b) A solution containing 0.510 g of an unknown monoprotic acid, HA, was titrated with 0.100 mol dm^{-3} NaOH(aq). 25.0 cm^3 was required to reach the equivalence point.

(i) Calculate the amount, in mol, of NaOH(aq) used. [1]

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(ii) Calculate the molar mass of the acid. [1]

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(iii) Calculate $[H^+]$ in the NaOH solution. [1]

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8. The Bombardier beetle sprays a mixture of hydroquinone and hydrogen peroxide to fight off predators. The reaction equation to produce the spray can be written as:

$$\underset{\text{hydroquinone}}{C_6H_4(OH)_2(aq)} + H_2O_2(aq) \rightarrow \underset{\text{quinone}}{C_6H_4O_2(aq)} + 2H_2O(l)$$

(a) (i) Calculate the enthalpy change, in kJ, for the spray reaction, using the data below. [2]

$C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g)$ $\Delta H^{\ominus} = +177.0\,kJ$

$2H_2O(l) + O_2(g) \rightarrow 2H_2O_2(aq)$ $\Delta H^{\ominus} = +189.2\,kJ$

$H_2O(l) \rightarrow H_2(g) + \frac{1}{2}O_2(g)$ $\Delta H^{\ominus} = +285.5\,kJ$

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(ii) The energy released by the reaction of one mole of hydrogen peroxide with hydroquinone is used to heat 850 cm^3 of water initially at 21.8°C. Determine the highest temperature reached by the water.

Specific heat capacity of water = 4.18 $kJ\,kg^{-1}\,K^{-1}$.

(If you did not obtain an answer to part (i), use a value of 200.0 kJ for the energy released, although this is not the correct answer.) [2]

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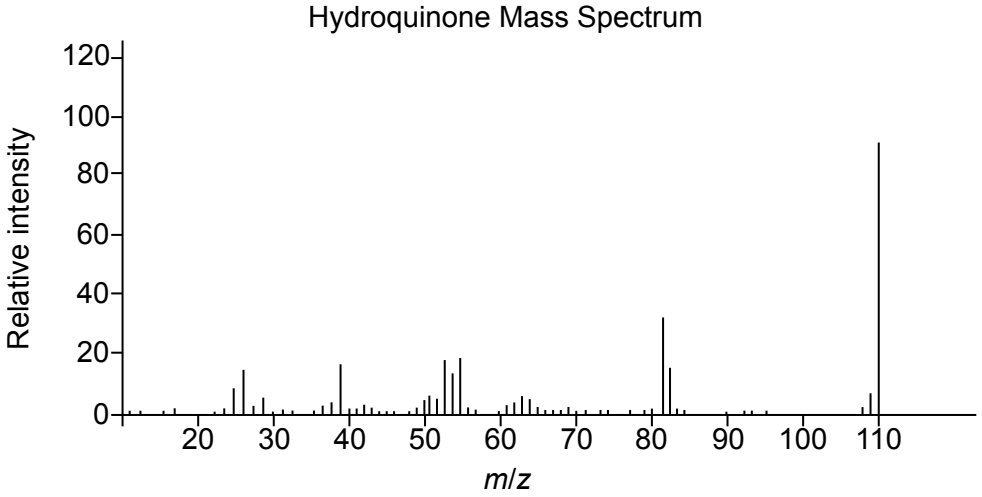
(Question 8 continued)

(b) Identify the species responsible for the peak at $m/z = 110$ in the mass spectrum of hydroquinone. [1]



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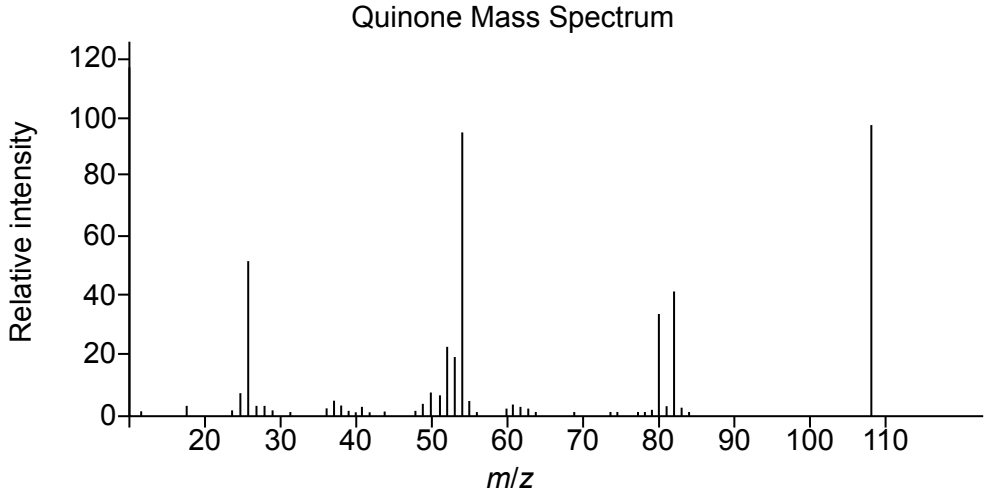
(c) Identify the highest m/z value in the mass spectrum of quinone. [1]



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