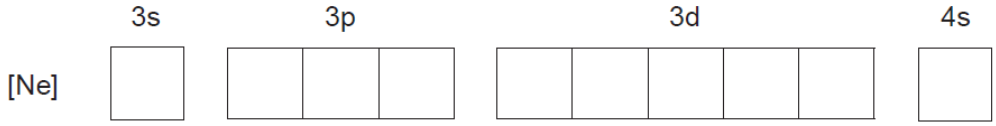
GCE A LEVEL CHEMISTRY

S21-A410

Assessment Resource F

Physical and Inorganic Chemistry

1. Complete the diagram below, using arrows to represent electrons, to show the electron arrangement for an atom of cobalt. [1]



2. Complete the definition below.

Relative atomic mass is the average mass of an atom of an element compared to

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3. *(a)* Selenium is an element in the p-block of the Periodic Table.

What information regarding the electronic structure of the selenium atom can be deduced from this statement? [1]

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(b) The illustration below gives some information about the elements surrounding selenium in the Periodic Table.

S
Sulfur
electronegativity = 2.58
boiling temperature = 445
first ionisation energy = 1000
standard electrode potential
for S(+6) → S(+4) = +0.16 V

As
Arsenic
electronegativity = 2.18
boiling temperature = 603
first ionisation energy = 947

Se
Selenium
electronegativity = ?
boiling temperature = 685
first ionisation energy = ?
standard electrode potential
for Se(+6) → Se(+4) = ?

Br
Bromine
electronegativity = 2.96
boiling temperature = 60

Te
Tellurium
electronegativity = 2.10
boiling temperature = 990
standard electrode potential
for Te(+6) → Te(+4) = +1.18 V

All ionisation energies are given in kJ mol^{-1} and all temperatures in °C

(i) Both sulfur and selenium have molecules containing rings of eight atoms.

Explain the difference in their boiling temperatures. [2]

(ii) Suggest values for the missing properties of selenium. Use the ideas you have studied to explain the values you have chosen. [6 QER]

(c) One radioactive isotope of selenium is selenium-75. It can be used as a medical tracer to identify cartilaginous tumours.

(i) The half-life of selenium-75 is 120 days. Samples are provided that have eight times higher concentration of selenium-75 atoms than the minimum needed for use as a tracer.

Find the maximum time a sample can be stored before the concentration of selenium-75 becomes too low to use. [2]

Time = ... days

(ii) Selenium-75 does not emit alpha particles when it decays.

Explain why this is important for its use as a medical tracer. [2]

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(d) Selenium dioxide, SeO_2, is a foul smelling solid, with a smell resembling rotting horseradish. It can be used to oxidise alkenes.

$$SeO_2 + C_3H_6 + H_2O \longrightarrow H_2SeO_2 + C_3H_6O$$

In an oxidation experiment, 2.70 g of C_3H_6 produced a yield of 62 % of C_3H_6O.

Calculate the mass of C_3H_6O formed. [2]

Mass = ... g

4. Ammonia, NH_3, and hydrazine, NH_2NH_2, are both compounds containing only nitrogen and hydrogen.

(a) The production of ammonia in the Haber process uses nitrogen and hydrogen gases as starting materials, a pressure of 200 atm and a temperature of 400 °C. The reaction occurring is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -94\,kJ\,mol^{-1}$$

(i) Explain fully why a pressure of 200 atm is used for this reaction. [3]

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(ii) The enthalpy change value given above is not the standard enthalpy change of formation for ammonia. Give **one** reason why this is not the standard enthalpy change of formation. [1]

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(iii) Write an expression for the equilibrium constant, K_c, for this reaction. [1]

(iv) State the effect (if any) of increasing temperature on the value of K_c. Give a reason for your answer. [2]

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(v) A mixture of nitrogen and hydrogen has an initial concentration of 0.020 mol dm^{-3} of each gas. The mixture is allowed to come to equilibrium in a fixed volume.

In the equilibrium mixture 20 % of the nitrogen gas had been converted into ammonia. Calculate the value of K_c under these conditions. [3]

K_c = ...

(b) The standard enthalpy change of formation for ammonia is −46 kJ mol^{-1} and for hydrazine it is +51 kJ mol^{-1}.

(i) State what information these values provide about the stability of these molecules. [1]

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(ii) One method of producing hydrazine is to oxidise ammonia using an appropriate oxidising agent, such as hydrogen peroxide.

$2NH_3(g) + H_2O_2(l) \longrightarrow NH_2NH_2(l) + 2H_2O(l)$ $\Delta H^\theta = -241\ kJ\,mol^{-1}$

Substance	Standard enthalpy change of formation, $\Delta_f H^\theta$ / kJ mol^{-1}	Standard entropy, S^θ / J K^{-1} mol^{-1}
$NH_3(g)$	−46	193
$NH_2NH_2(l)$	+51	122
$H_2O_2(l)$		102
$H_2O(l)$	−286	70

I. Calculate the standard enthalpy change of formation of hydrogen peroxide, H_2O_2. [2]

$\Delta_f H^\theta$ = ... kJ mol^{-1}

II. Calculate the temperature at which the value of ΔG^θ is equal to zero. [3]

T = ... K

III. A student states that the temperature calculated in part II is the minimum temperature required for the reaction to occur. Is the student correct? Give a reason for your answer. [2]

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(iii) An alternative route for producing hydrazine starts with the molecule urea, which is produced in biological systems.

$$(NH_2)_2CO + NaOCl + 2NaOH \longrightarrow N_2H_4 + H_2O + NaCl + Na_2CO_3$$

Give **one** disadvantage of this route over the production of hydrazine from ammonia. [1]

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(iv) Hydrazine can undergo both oxidation and reduction reactions. Electrochemical potentials for both processes are included in the table below.

	Standard electrode potential, $E^{\ominus}$ / V
$Co^{3+}(aq) + e^- \rightleftharpoons Co^{2+}(aq)$	+1.82
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$N_2H_4(aq) + 4H_2O(l) + 2e^- \rightleftharpoons 2NH_4^+(aq) + 4OH^-(aq)$	+0.11
$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	–0.26
$Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$	–0.42
$N_2(g) + 4H_2O(l) + 4e^- \rightleftharpoons N_2H_4(aq) + 4OH^-(aq)$	–1.15

I. Suggest whether addition of sodium hydroxide to a hydrazine solution will favour its use as a reducing agent. Give a reason for your answer. [2]

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II. Identify which of these four M^{3+} ions (if any) can be reduced by hydrazine under standard conditions. Give a reason for your answer. [2]

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