Semester Two Examination 2009

Question/Answer Booklet

YEAR 12 CHEMISTRY

Name: _____

Time allowed for this paper

Reading time before commencing work: Ten minutes

Working time for paper: Three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet

Separate Multiple Choice Answer Sheet

Chemistry Data Sheet (inside front cover of this Question/Answer Booklet)

To be provided by the candidate

Standard items: Pens pencils, eraser or correction fluid, ruler

Special items: A 2B, B or HB pencil for the separate Multiple Choice Answer Sheet and calculators satisfying the conditions set by the Curriculum Council for this subject.

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the

examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Part	Number of questions available	Number of questions to be attempted	Suggested working time	Marks available
1. Multiple choice	30	All	55 min	60 (30%)
2. Short answers	12	All	60 min	70 (35%)
3. Calculations	6	All	45 min	50 (25%)
4. Extended answers	1	All	20 min	20 (10%)
			Total marks	200 (100%)

Instructions to candidates

1. Answer the questions according to the following instructions:

   Part 1 Answer all questions, using a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do not use a ball point or ink pen.

   If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers.

   Parts 2, 3 and 4 Write your answers in the spaces provided in this Question/Answer Booklet. A blue or black ball point pen or ink pen should be used.

   Questions containing specific instructions to show working should be answered with a complete logical, clear sequence of reasoning showing how the final answer was arrived at; correct answers which do not show working will not be awarded full marks.

2. **Chemical equations**

   For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be ions, molecules or solids.

Teacher use only:

	Mark	Out of
Part One		
Part Two		
Part Three		
Part Four		

Total		

PART 1 **(60 marks = 30 % of paper)**

Answer ALL questions on the separate multiple choice answer sheet provided. Each question in this part is worth 2 marks.

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1. Which one of the following species does not have an electron configuration corresponding to a noble gas?

   a) Rb^{+}
   b) Se^{2-}
   c) At^{-}
   d) H^{+}

2. Covalent bonds are most commonly found between

   a) gaseous and solid elements.
   b) elements with low first ionisation energies.
   c) elements with a large difference in first ionisation energies.
   d) elements with similar but relatively high first ionisation energies.

3. The chemical properties of an atom are MAINLY influenced by the

   a) mass of the nucleus.
   b) number of electrons in the valence shell.
   c) number of neutrons in the nucleus.
   d) combined total of protons and electrons.

4. The electronic structure of a neutral atom is

   $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 5s^2$

   If its nucleus contains 11 more neutrons than protons, what would be its atomic mass?

   a) 87
   b) 38
   c) 49
   d) 103

5. An element Z has the following five successive molar ionisation energies (in kJ mol^{-1}):

   740 1500 7700 10500 13600

   What would be the formula of the compound formed when Z reacts with oxygen?

   a) Z_2O
   b) ZO

c) Z_2O_3
d) ZO_2

6. Which one of the following statements is not true of elements in the periodic table?

a) They are arranged in ascending order of atomic number.
b) Elements with high ionisation energy are located on the right-hand side of the table.
c) The halogens are located among the non-metals.
d) Transition metals appear in the first two columns of the table.

7. Elements X and Y have the following electron configurations

X: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
Y: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

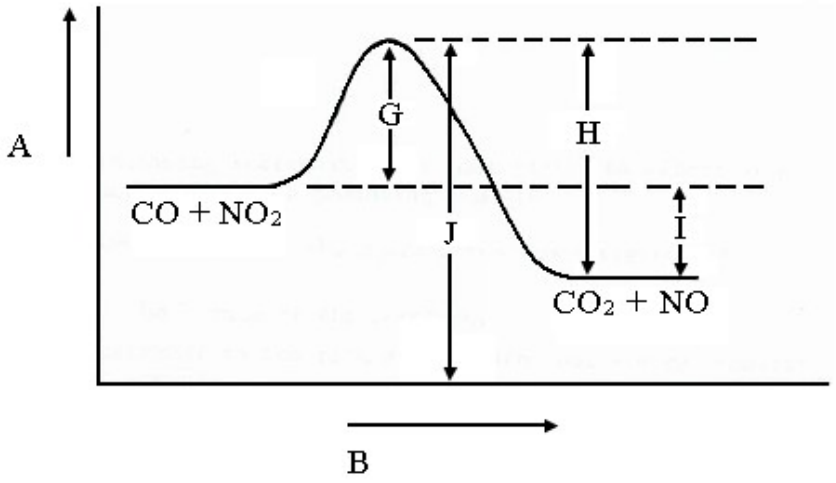
Which one of the following would be the formula of the compound formed when X reacts with Y?

a) YX_2
b) XY
c) Y_2X_5
d) XY_2

Questions 8, 9 and 10 refer to the potential energy diagram below for the reaction:

$$CO + NO_2 \rightarrow CO_2 + NO$$

The axes are not labelled.



8. Which one of the following statements is TRUE?

a) The axis representing potential energy is B.

b) In the forward reaction, the potential energy of the reactants is lower than that of the products.
c) The potential energy of the 'activated complex' is J.
d) The activation energy for the forward reaction is J minus G.

9. The heat of reaction for the forward reaction is given by

a) J.
b) H.
c) J minus H.
d) I.

10. The activation energy for the reverse reaction

$$CO_2 + NO \rightarrow CO + NO_2$$

is given by

a) J.
b) G.
c) H.
d) J minus H.

11. Which one of the following statements BEST describes the effect of a catalyst in the Haber process for producing ammonia?

a) It leads to an increase in the equilibrium concentration of ammonia.
b) It increases the rate of the reaction.
c) It causes a decrease in the rate of reaction, but a more complete conversion to ammonia.
d) It reduces the pressure needed for the reaction.

12. Which one of the following is the best statement of Le Chatelier's principle?

a) If a system is at equilibrium and some change is made in the conditions, net reaction occurs in the direction that partially counteracts the effect of the change.
b) If a system is at equilibrium and some change is made in the conditions, the equilibrium constant changes in a way that counteracts the effect of the change.
c) An increase in pressure will favour the formation of products.
d) The concentrations of reactants and products must remain equal no matter what changes are made to the system.

Question 13 and 14 refer to the following reaction:

$$2CO(g) + 2F_2(g) + CCl_4(g) \Leftrightarrow CF_4(g) + 2COCl_2(g) \quad \Delta H = -766 \text{ kJ}$$

13. When the system has reached equilibrium, which one of the following statements is TRUE?

    a) The number of moles of CCl_4 equals the number of moles of CF_4.
    b) The rate of the forward reaction is greater than the rate of the reverse reaction.
    c) Reaction is continuing but the concentration of all components remains constant.
    d) The concentration of the reactants equals the concentration of the products.

14. Which set of reaction conditions would produce the highest yield of products?

    a) High pressure, low temperature.
    b) Low pressure, high temperature.
    c) Low pressure, low temperature.
    d) High pressure, high temperature.

15. What is the pH of the solution obtained when 90.0 mL of water is added to 10.0mL of 0.1 mol L^{-1} nitric acid?

    a) 4
    b) 3
    c) 2
    d) 1

16. Which one of the following groups consists ONLY of substances which give alkaline solutions (pH >7) when added to water?

    a) Potassium nitrate, sodium acetate (sodium ethanoate) and ammonia.
    b) Ammonium chloride, sodium hydroxide and ammonia.
    c) Potassium carbonate, sodium acetate and ammonia.
    d) Ammonium nitrate, sodium hydroxide and ammonia.

17. The correct order of increasing boiling points for the substances silica (SiO_2), propane (C_3H_8), ethanol (CH_3CH_2OH) and helium (He) is

    a) silica < helium < propane < ethanol.
    b) helium < propane < ethanol < silica.
    c) helium < ethanol < propane < silica.
    d) helium < propane < silica < ethanol.

18. Two white solids are insoluble in water, but dissolve readily in dilute hydrochloric acid.

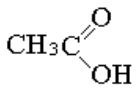
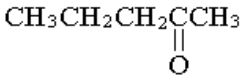
    The solids could be

    a) Li_2CO_3 and KOH.
    b) $Mg(OH)_2$ and $CaCO_3$
    c) $Cr(OH)_3$ and MnO_2
    d) $CaCl_2$ and $BaSO_4$

19. Which one of the following solutions would have the lowest pH?

a) 0.1M HCl
b) 0.1M Na_2CO_3
c) 0.1M CH_3COOH
d) 0.1M H_2SO_4

20. Which one of the following compounds will have the highest solubility in water?

a) $CH_3CH_2CH_2CH_2OH$
b) $CHCl_3$
c) 
d) 

21. What is the oxidation state of manganese in the manganate ion, MnO_4^{2-}?

a) +6
b) +7
c) +4
d) +2

22. Which one of the following will not conduct an electric current?

a) Molten sodium chloride
b) Dilute nitric acid
c) Molten sulfur
d) Mercury

23. Which one of the following is not a property of zinc?

a) Strong oxidising agent.
b) Dissolves in acids liberating hydrogen gas.
c) Forms Zn^{2+} ions in most of its compounds.
d) Forms the $Zn(NH_3)_4^{2+}$ complex ion.

Questions 24 and 25 refer to the following UNBALANCED equation:

$$I^-(aq) + IO_3^-(aq) + H^+(aq) \rightarrow I_2(s) + H_2O$$

24. When the equation is balanced with lowest whole number coefficients, what is the coefficient in front of $H^+(aq)$?

a) 6
b) 4
c) 3
d) 2

25. Which one of the following statements is true?

a) This is a disproportionation, not a reduction-oxidation reaction.
b) The IO_3^- ion is not the oxidising agent.
c) The oxidising agent is $I_2(s)$.
d) The I^- ion is the reducing agent.

26. Which one of the following compound has a tetrahedral shape and is also a polar molecule?

a) CCl_4
b) CS_2
c) CH_3Br
d) SF_6

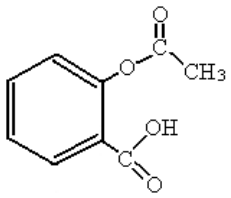
27. Which one of the following solutions would oxidise a 1 mol L^{-1} $Cl^-(aq)$ solution to Cl_2? (All solutions are 1 mol L^{-1} in the reagent).

a) Acidified $Cr_2O_7^{2-}$
b) Nitric acid
c) Br^-
d) Acidified H_2O_2

28. Hexane will NOT dissolve in water because

a) there is no chemical reaction between hexane and water.
b) hexane cannot form hydrogen bonds with water.
c) the intermolecular forces within the two liquids are weak.
d) the hexane molecule is larger than the water molecule.

29. Aspirin, whose structure is shown, contains which functional groups?



a) A ketone and an alcohol.
b) An alcohol and a carboxylic acid.
c) An ester and a carboxylic acid.
d) A ketone, an alcohol and an ester.

30. Which one of the following slows down the corrosion of a small strip of iron?

a) Placing the iron under stress.
b) Attaching a length of zinc to the iron.
c) Attaching a length of copper to the iron.
d) Storing the iron under water.

PART 2 **(70 marks = 35 % of paper)**

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1. Write equations for any reactions that occur in the following procedures. If no reaction occurs write 'no reaction'.
In each case, describe **in full** what you would observe, including any
- Colours
- Odours
- Precipitates (give the colour)
- Gases evolved (give the colour or describe as colourless)

If no change is observed, you must state this as the observation.

(a) Solid copper (II) oxide is reacted with dilute hydrochloric acid.

Equation_____

Observation _____

_____

(3 marks)

(b) Zinc granules are added to a solution of iron (II) nitrate.

Equation_____

Observation _____

_____

(3 marks)

(c) Concentrated ammonia solution is added to a suspension of silver sulfide.

Equation_____

Observation _____

_____

(3 marks)

(d) A solution of magnesium nitrate is added to a solution of potassium phosphate.

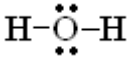
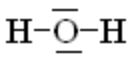
Equation _____

Observation _____

_____

(3 marks)

2. For each species listed in the table below, draw the structural formula, representing all valence shell electron pairs either as **:** or **–**

[for example, water  or  or  and so on]

Species	Electron-dot diagram
Methanamine CH_3NH_2	
Nitrate ion NO_3^-	

Potassium phosphate K_3PO_4	

(6 marks)

3. For each of the following pairs of substances describe a chemical test and observation by which you could distinguish between the substances listed. You must indicate which of the substances gives rise to the observation. No equations are necessary.

Substances	What you would do	What you would see
2-methyl-2-propanol and 2-propanol		
Propanoic acid and propanone		

(6 marks)

4. Hypochlorous acid HClO is a weak acid and barium hydroxide solution $Ba(OH)_2$ is a strong base. When chemically equivalent amounts of these solutions are mixed barium hypochlorite is formed. Explain why this salt solution is basic.

(3 marks)

5. A compound commonly used in soaps is sodium stearate, $NaC_{17}H_{35}COO$. The cleaning action of soap is very much reduced in acidic conditions because the stearate ions react to form stearic acid, $C_{17}H_{35}COOH$.
   (a) Write an equation to show the formation of this acid.

   (b) Explain why stearic acid molecules are not as effective in their cleaning action as stearate ions.

(4 marks)

6. An impure sample of copper contains iron and silver impurities. For the electrowinning of copper from this sample, describe and explain:

(a) what happens to the copper.

(b) what happens to the iron.

(c) what happens to the silver.

(6 marks)

7. Identify by name or formula an example of each of the following.

Description	Name or Formula
An aromatic aldehyde	
A compound which is a liquid at room temperature and whose molecules are hydrogen bonded together	
A substance that can be used as a primary standard in redox titrations	
A secondary alcohol	
A positively charged complex ion	
A solution that will dissolve aluminium oxide but not iron (III) oxide	

A gas which forms a basic solution in water	
The major product of the Contact Process	

(8 marks)

8. Both osmium (I) acetate and osmium (III) acetate are soluble in water. Use the following observations to help you make an estimate of the Standard Reduction Potential for the half-reaction

$$Os^{3+} + 2e^- \rightarrow Os^{+}$$

Observations
Osmium (I) acetate solution decolourises bromine water but does not turn iron (III) sulfate solution green.
When osmium (III) acetate solution is added to potassium iodide solution a brown colour is produced.

The value of E^o lies between _____ V and _____V.

(2 marks)

9. A series of solutions of hydrochloric acid with different concentrations was prepared and tested with the indicator, erythrosin. The results of the experiment are set out below.

pH	**Indicator colour**
1	Yellow
2	Yellow
3	Orange
4	Red

On the basis of these results, what can be concluded about the suitability of erythrocin for titrations involving hydrochloric acid and sodium carbonate solution? Justify your answer with equations.

(4 marks)

10. Write a structural formula to represent an example of each of the following.

A non-polar molecule that contains only polar bonds	
A polar molecule that contains only polar bonds	
A polar molecule that will hydrogen bond with water	
A non-polar molecule that contains at least one non-polar bond	

(4 marks)

11. In the chemical equilibrium system:

$$Fe^{3+}(aq) + SCN^{-}(aq) \Leftrightarrow FeSCN^{2+}(aq)$$

The Fe^{3+} ions are brown, SCN^{-} ions are colourless and the $FeSCN^{2+}$ ions are deep red. Their concentration in the equilibrium mixture can be estimated by the intensity of their colour.

The concentration of Fe^{3+} in this solution can be reduced by the addition of fluoride ions which form a series of colourless complex ions in solution.

$Fe^{3+} + F^{-} \rightarrow FeF^{2+}$

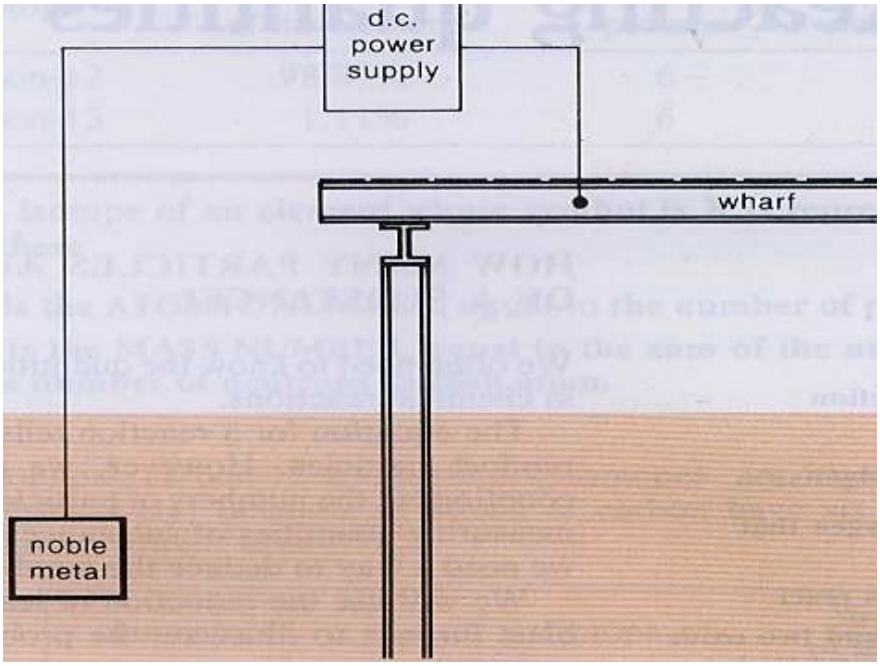
$Fe^{3+} + 2F^{-} \rightarrow FeF_2^{+}$

A solution was prepared by mixing KSCN solution with $Fe(NO_3)_3$ solution and it was then divided into four portions in petri dishes. The dishes were treated differently as shown in the table below. Describe how each dish would appear, compared to dish 1 and explain your answer in each case.

Dish	**Action**	**Observation (compared to dish 1)**	**Explanation**
Dish 1	No change	Same	No answer required
Dish 2	KSCN crystals added		
Dish 3	$Fe(NO_3)_3$ crystals added		
Dish 4	NaF crystals added		

(8 marks)

12. Shown below is a diagrammatic representation of a steel wharf which is protected from corrosion by application of an emf between the wharf and a lump of noble metal (probably copper).



On the diagram indicate

(a) the direction of electron flow.

(b) the direction of the flow of sodium ions in the sea water.

(c) the direction of the flow of chloride ions in the sea water.

(d) the anode.

(e) the cathode.

(f) Write the equation for the reaction at the anode.

(g) Write the equation for the reaction at the cathode.

(7 marks)

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PART 3 **(50 marks = 25 % of paper)**

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer Booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. Express your final numerical answers to three (3) significant figures where appropriate and provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you don't you will lose marks.

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1. A solid carboxylic acid has two hydrogen ions per molecule and is hydrated in its crystalline form. On heating at 110ºC for twenty minutes, 1.616 g of the hydrated solid had its mass reduced to 1.152 g of anhydrous powder.

(a) What is the percentage by weight of water in the hydrated acid crystals?

A 4.100 g sample of the hydrated acid was dissolved in water and the solution made up to 500 mL in a volumetric flask. Titration of 20.00 mL aliquots of this solution against 0.1100 mol L^{-1} sodium hydroxide solution required a volume of 23.70 mL.

(b) Calculate the molar mass of the hydrated carboxylic acid.

(c) Determine the molar mass of the anhydrous acid.

(d) Suggest a structure for the anhydrous carboxylic acid.

[9 marks]

2. The amount of the metal antimony (Sb) present in a sample of fish muscle tissue may be determined in the following way.
The muscle is boiled in concentrated nitric acid until all of the antimony has been oxidised to antimonous acid, H_3SbO_4 and the acid has been reduced to nitrogen dioxide and water.

This antimonous acid is then treated with concentrated hydroiodic acid.

$$2H_3SbO_4 + 2H^+ + 2I^- \rightarrow 2H_2SbO_3 + I_2 + 2H_2O$$

The iodine produced in this way may be titrated with sodium thiosulfate solution.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

If 206.9g of muscle tissue were treated in this way and needed 44.25 mL of 0.2000 $molL^{-1}$ sodium thiosulfate solution, calculate the percentage by mass of antimony in the tissue.

[6 marks]

3. An early stage in the manufacture of ammonia involves the production of hydrogen from methane according to this reaction:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

The hydrogen is then reacted with nitrogen gas to form the ammonia in the Haber Process.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

In a production run, 5.00×10^5 L of methane at a pressure of 110 kPa and a temperature of 105°C is converted to carbon monoxide and hydrogen. This process has an efficiency of 73%. Determine the volume of ammonia that could be formed from this hydrogen if measured at 550°C and 25000 kPa if the Haber Process is 40% efficient.

(6 marks)

4. An aluminium ore contains the minerals Gibbsite and Bohemite. Each of these minerals is pure Al_2O_3. The ore yielded 30% of its mass as aluminium oxide when treated in the Bayer Process.
90% of the mineral content of the ore was identified as Gibbsite and 10% as Bohemite.

(a) Calculate the time taken to produce 1 tonne (1×10^6 g) of aluminium by electrolysis in the Hall-Herault Process if the current used was 5.00×10^4 A.

(b) Calculate the mass of pure aluminium oxide required to produce 1 tonne of aluminium.

(c) Calculate the mass of aluminium ore needed to produce 1 tonne of aluminium from its Gibbsite content in this way.

[8 marks]

5. The presence of magnesium or calcium ions in tap water leads to a condition known as 'water hardness'.

A 250.0 L sample of tap water taken from a Perth home was found to contain 10.40 mg L^{-1} of calcium ions and 4.230 mg L^{-1} of magnesium.

In order to remove the hardness caused by these ions, an analyst added 20.00 g of sodium carbonate crystals, $Na_2CO_3.10H_2O$, to the 250.0 L of water to precipitate the offending ions as their carbonates.

(a) Calculate whether sufficient sodium carbonate had been added.

(b) Determine the mass of additional sodium carbonate crystals that need to be added or the mass of crystals that was in excess.

[9 marks]

6. A sample of organic waste material taken from a high school chemistry laboratory was analysed so that it could be safely disposed of.

The waste was found to contain a compound made up of the elements carbon, hydrogen, sulfur, nitrogen and oxygen.

A 5.000 g sample of the compound burned to produce 5.359 g of carbon dioxide and 3.291 g of water.

A further 10.00 g sample of the compound was treated with concentrated hydrochloric acid and released 909.6 mL of nitrogen gas at STP. This sample was then added to barium chloride solution to precipitate all the sulfur as barium sulfate. The precipitate weighed 18.950 g.

The molar mass of the compound was found to be 123.2.

Determine the formula of this substance and suggest a possible structure.

[12 marks]

PART 4 (20 marks = 10% of paper)

Answer the following extended answer question. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing.
Marks are awarded principally for the relevant chemical content of your answer, and also for coherence and clarity of expression. Your answer should be presented in about $1^{1/2}$ to 2 pages on the lined paper after the questions.

Extraction of Nickel

In 1899 Ludwig Mond developed a process for extracting and purifying nickel. The so-called "Mond Process" involves the conversion of nickel oxides to pure nickel metal. The oxide is obtained from nickel ores by a series of treatments including concentration, roasting and smelting of the minerals.
In the first step of the process, nickel oxide is reacted with water gas, a mixture of H_2 and CO, at atmospheric pressure and a temperature of 50°C. The oxide is thus reduced to impure nickel. This process makes use of the fact that carbon monoxide complexes with nickel readily and reversibly to give nickel tetracarbonyl, $Ni(CO)_4$. No other element forms a carbonyl compound under the mild conditions used in the process.
This compound decomposes on heating to about 230°C to give pure nickel metal and CO, which can then be recycled.

The process can be summarised as follows:

$$\underset{\text{(impure)}}{Ni} + 4CO \xrightarrow{50^\circ C} Ni(CO)_4 \xrightarrow{230^\circ C} \underset{\text{(pure)}}{Ni} + 4CO.$$

but actually consists of three steps.

1. Nickel oxide is reacted with water gas at 200 °C to remove oxygen, leaving impure nickel. Impurities include iron and cobalt.

$$NiO\ (s) + H_2\ (g) \rightarrow Ni\ (s) + H_2O\ (g)$$

2. The impure nickel is reacted with excess carbon monoxide at 50 - 60°C to form nickel carbonyl.

$$Ni\ (s) + 4\ CO\ (g) \rightarrow Ni(CO)_4\ (g)$$

3. The mixture of excess carbon monoxide and nickel carbonyl is heated to 220 - 250°C. On heating, nickel tetracarbonyl decomposes to give pure nickel.

$$Ni(CO)_4\ (g) \rightarrow Ni\ (s) + 4\ CO\ (g)$$

Discuss the similarities and differences that exist between the Mond Process and the extraction of iron in the Blast Furnace.