Question 40 **(17 marks)**

Nickel mining is one of the largest mining industries in Western Australia. One process for extracting nickel from nickel oxide ore is the Mond process, which was developed at the end of the 19th Century.

Step 1
Nickel(II) oxide is reacted with hydrogen to produce nickel metal and water at 200 °C, according to the equation:

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

The nickel produced is impure and must be further purified.

Step 2
The impure nickel is reacted with carbon monoxide to produce nickel carbonyl ($Ni(CO)_4$).

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

The impurities in the nickel are left as solids and separated.

Step 3
The nickel carbonyl gas is then passed over a platinum catalyst, causing the compound to decompose.

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

(a) If the nickel produced in Step 1 is 95.7% pure, calculate the mass of nickel(II) oxide that would be required to produce 2245 tonne of the impure nickel. (5 marks)

(b) In Step 2, if the impure nickel mixture contains 521 tonne of pure nickel and produces 1025 tonne of $Ni(CO)_4$, calculate the percentage yield of this reaction. (4 marks)

(c) A 19.22 g sample of the impure nickel from Step 1, on page 34, was reacted with 90.00 mL of a 5.02 mol L^{-1} solution of nitric acid. This reaction can be represented by the following equation:

$$3\ Ni(s) + 8\ HNO_3(aq) \rightarrow 3\ Ni(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(\ell)$$

Calculate the volume of nitrogen monoxide produced measured at standard temperature and pressure (STP). (8 marks)