NAME_____

Year 11 Chemistry Assignment
Chemical Industry

1. Draw a flowchart for any process that is familiar to you.
   Include raw materials, by-products, and waste products. /3

2. The Haber Process is used to produce ammonia (NH_3) which is an important component in pharmaceuticals and cleaning agents. The equation for the Haber Process is:

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

   Nitrogen and hydrogen gas do not react at room temperature unless a suitable catalyst is added.

   (a) Explain, using an energy profile diagram, why the reaction at room temperature only occurs when a catalyst is added. /3

   (b) State how nitrogen and hydrogen could be made to react without a catalyst present. /1

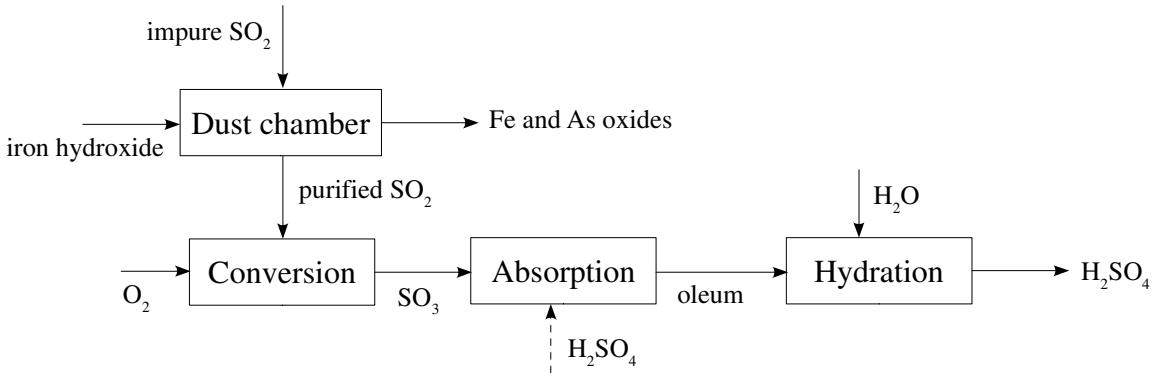
   (c) The Haber Process is carried out under high pressure conditions.

   (i) State why the forward reaction decreases the pressure. /1

   (ii) Hence explain, using Le Chatelier's Principle, why increasing the pressure favours the forward reaction. /2

   (iii) State one advantage and one disadvantage for the manufacturer of using high pressure. /2

3. Sulfuric acid is produced industrially by the Contact Process, shown in the flowchart below:



   (a) Show where the H_2SO_4 in the Absorption step would come from, by completing the arrow on the flowchart above. /1

   (b) State two raw materials required for the Contact Process. /1

   (c) State one waste product and suggest what the manufacturer should do with it. /2

   (d) Describe how the final product would be different if the Dust chamber step was omitted (skipped). /2

   (e) In the Conversion step, the gas mixture is passed as slowly as possible over several layers of small catalyst pellets. The equation for this step is:

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)} \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

   (i) Explain why the catalyst is in pellet form rather than large blocks or lumps. /2

   (ii) The catalyst pellets only need to be replaced every ten years. State a reason for this. /1

   (iii) Explain why increasing the temperature would favour the backward reaction. /3

   (iv) Evaluate, with reference to rate, yield, and cost, the temperature conditions that should be used for this reaction. /3

TOTAL MARKS /27