The Mole Concept

Question 1

(*a*) A mixture of potassium nitrate and sulfur reacts according to the following balanced equation.

$$4KNO_{3\,(s)} + 5S_{(s)} \rightarrow 2K_2O_{(s)} + 2N_{2\,(g)} + 5SO_{2\,(g)}$$

One of the two reactants is in stoichiometric excess when 20.2 g of potassium nitrate is mixed with 24.0 g of sulfur.

(*i*) Which reactant is in excess?
What mass of this reactant is unused at the end of the reaction? (13)

(*ii*) Calculate the total volume (in litres) of gaseous products, measured at s.t.p., formed in the reaction. (6)

(*iii*) What mass of solid is produced? (6)

Question 2

(*c*) Silicon dioxide reacts vigorously with magnesium powder to form magnesium silicide, a dark blue solid. When magnesium silicide dissolves in hydrochloric acid, the silane gas produced ignites spontaneously when it comes into contact with oxygen in the air. The balanced equations for these reactions are given below.

$$SiO_2 + 4Mg \rightarrow Mg_2Si + 2MgO$$

$$Mg_2Si + 4HCl \rightarrow SiH_4 + 2MgCl_2$$

$$SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$$

(*i*) What is meant by *a mole* of a substance? (6)

(*ii*) How many moles of magnesium react with silicon dioxide to produce 7.6 g of magnesium silicide? (6)

(*iii*) Calculate the number of moles of hydrogen chloride required to react with 7.6 g of magnesium silicide.
What mass of magnesium chloride is produced? (9)

(*iv*) What volume of oxygen gas, measured at room temperature and pressure, is required for the complete combustion of the silane produced from 7.6 g of magnesium silicide? (4)

Question 3

(*f*) What is meant by *one mole* of a substance?

Question 4

(*b*) From July 2008 changes will apply to the way in which taxes are levied on new cars bought in Ireland. Vehicles that, in controlled tests, have higher levels of carbon dioxide emission per kilometre travelled will be subject to higher levels of taxation. The measures are designed to encourage the purchase of cars that are more fuel-efficient and have lower CO_2 emissions.

The manufacturer's specification for a certain diesel-engined car is 143 g CO_2 / km (i.e. the car produces 143 g of CO_2 for every kilometre travelled). The car is used for morning and afternoon school runs totalling 8 km per day.

Use the manufacturer's CO_2 emission figure to calculate the amount of CO_2 produced each day during the school runs in terms of

(*i*) the mass of CO_2, (*ii*) the number of moles of CO_2,

(*iii*) the volume of CO_2 at room temperature and pressure. (18)

If a large SUV (sports utility vehicle) with a CO_2 emission rating of 264 g CO_2 / km were used instead of the car mentioned above, how many more litres of CO_2 would be released into the atmosphere per day during the school runs? (7)