Year 13 Science: Chemical processes in the world: from natural gas to urea

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Write the balanced equation for urea hydrolysing in the soil.

2. What happens to the equilibrium yield of ammonia if the pressure is increased, and why?

3. Overall, $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ and $N_2 + 3H_2 \rightarrow 2NH_3$. What is the minimum mass of CO_2 released in making 1.00 tonne of NH_3?

4. If ocean pH fell from 8.1 to 7.8, by what factor would $[H_3O^+]$ increase?

5. Why does the Haber process use a catalyst, when it does not change the equilibrium yield?

Fix the mistake

6. Correct this statement: "The catalyst increases the yield of ammonia."

7. Correct this statement: "Plants use a high temperature because the Haber process needs heat."

8. Correct this statement: "Urea fertiliser releases nitrate, which harms the environment."

9. Correct this statement: "The report lists five problems with fertiliser, so it is an evaluation."

Answer key (for parents and tutors)

1. Write the balanced equation for urea hydrolysing in the soil.
   $(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$.

2. What happens to the equilibrium yield of ammonia if the pressure is increased, and why?
   The yield increases: the forward reaction turns 4 mol of gas into 2 mol, so the equilibrium shifts right to reduce the pressure.

3. Overall, $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ and $N_2 + 3H_2 \rightarrow 2NH_3$. What is the minimum mass of CO_2 released in making 1.00 tonne of NH_3?
   4 mol H_2 make 8/3 mol NH_3 for each mol of CO_2, so $n(CO_2) = 3/8 \times n(NH_3)$; $n(NH_3) = 1.00 \times 10^6 \div 17.0 = 5.882 \times 10^4$ mol, $n(CO_2) = 0.375 \times 5.882 \times 10^4 = 2.206 \times 10^4$ mol, $m = 2.206 \times 10^4 \times 44.0 = 9.71 \times 10^5$ g = 0.971 t (real plants release more, because they also burn gas for heat).

4. If ocean pH fell from 8.1 to 7.8, by what factor would $[H_3O^+]$ increase?
   $10^{0.3} = 2.0$, so $[H_3O^+]$ doubles.

5. Why does the Haber process use a catalyst, when it does not change the equilibrium yield?
   It lowers the activation energy, so equilibrium is reached quickly at a lower temperature than would otherwise be needed, which keeps the yield higher and saves energy.

6. Correct this statement: "The catalyst increases the yield of ammonia."
   A catalyst speeds up the forward and reverse reactions equally, so equilibrium is reached faster but the yield at equilibrium is the same.

7. Correct this statement: "Plants use a high temperature because the Haber process needs heat."
   The forward reaction is exothermic, so heat lowers the yield; the high temperature is only there to give a fast enough rate.

8. Correct this statement: "Urea fertiliser releases nitrate, which harms the environment."
   Give the chain with equations: urease makes ammonia, bacteria oxidise it to nitrate, and nitrate leaches because soil does not hold negative ions.

9. Correct this statement: "The report lists five problems with fertiliser, so it is an evaluation."
   An evaluation weighs consequences against each other and against the benefits, and reaches a judgement backed by the chemistry.