Grade 11 Chemistry, Explained

Unit 17 · Modern Chemical Manufactures

ANSWER KEY · FOR TEACHERS

Full marks 34

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Match the columns

1. oleum → **c.** sulphur trioxide absorbed in concentrated sulphuric acid, $H_2S_2O_7$
2. promoter → **d.** a substance such as K_2O that makes a catalyst work better and last longer
3. prills → **a.** small round beads of urea made by letting molten drops fall through air
4. biuret → **f.** an impurity formed when molten urea is held hot too long, harmful to seedlings
5. cell liquor → **g.** the solution of about 10–12% NaOH with salt drawn from a diaphragm cell
6. eutrophication → **b.** a huge growth of algae in water fed by washed-out nitrate and phosphate

Each carries 0.5 mark. K · 3

2 Label the diagram

1. Cl_2
2. diaphragm
3. steel cathode
4. H_2

Each carries 0.5 mark. K · 2

3 Multiple choice

i. **b.** K_2O and Al_2O_3 K · 1

Potassium oxide and aluminium oxide make the iron work better and last longer.

ii. **c.** calcium chloride K · 1

Ammonia and carbon dioxide are recovered and used again; overall $CaCO_3 + 2\,NaCl \rightarrow Na_2CO_3 + CaCl_2$.

iii. **b.** the reaction $2NO + O_2 \rightarrow 2NO_2$ goes faster at lower temperatures U · 1

The oxidation of nitric oxide is unusual: it goes faster at lower temperatures. The heat removed also raises steam.

iv. **c.** moist iron(III) hydroxide K · 1

Moist $Fe(OH)_3$ takes up the arsenic oxide, which would poison the V_2O_5 catalyst. The light beam (testing box) only checks the gas is clean.

v. **b.** phosphorus U · 1

Phosphorus helps the growth of roots and the formation of flowers, fruits and seeds.

4 Short answers

a. MARKING SCHEME U · 2

- ✓ With water the reaction is so violent that the acid forms as a fine mist that can't be collected.
- ✓ $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ and $H_2S_2O_7 + H_2O \rightarrow 2\,H_2SO_4$.

b. MARKING SCHEME U · 2

- ✓ It keeps chlorine and hydrogen apart (mixed, they can explode).
- ✓ The flow through it stops OH^- reaching the chlorine, which would react with it: $Cl_2 + 2\,NaOH \rightarrow NaCl + NaClO + H_2O$.

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

c. MARKING SCHEME K · 2

- ✓ Advantages, any two: the highest nitrogen of any solid fertilizer (46%); cheap per kilogram of nitrogen; suits all crops; easy to store and transport; no harmful residue.
- ✓ Disadvantages, any two: hygroscopic and cakes; loses ammonia to the air from moist soil surfaces; very soluble, so washed away; biuret harms seedlings.

d. MARKING SCHEME U · 3

- ✓ Nitrate and phosphate washed into the water.
- ✓ They feed an algal bloom.
- ✓ Bacteria decomposing dead algae use up the dissolved oxygen, and fish die.

5 Long answer

ANSWER U · 4

Oxidation of ammonia: ammonia mixed with about ten times its volume of air passes through platinum–rhodium (about 10% Rh) gauze at about 850 °C: $4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O$.
Oxidation of nitric oxide: the gas is cooled and meets more air in the oxidation chamber: $2\,NO + O_2 \rightarrow 2\,NO_2$.
Absorption: nitrogen dioxide with more air rises up a packed absorption tower against water trickling down: $4\,NO_2 + O_2 + 2\,H_2O \rightarrow 4\,HNO_3$, giving 50–68% acid.
Distilling alone stops at 68%; the acid is distilled under reduced pressure with concentrated sulphuric acid, which holds back the water, giving about 98%.

MARKING SCHEME

- ✓ Catalytic oxidation of ammonia on Pt–Rh at about 850 °C, with its equation.
- ✓ Oxidation of NO to NO_2 on cooling, with its equation.
- ✓ Absorption in water with air, with its equation.
- ✓ Concentration by distilling with conc. H_2SO_4.

6 Numerical problems

a. ANSWER A · 4

i. $S + O_2 \rightarrow SO_2$; $2\,SO_2 + O_2 \rightarrow 2\,SO_3$; $SO_3 + H_2O \rightarrow H_2SO_4$.
ii. Sulphur = 64×10^6 g ÷ 32 = 2.0×10^6 mol, giving 2.0×10^6 mol of $H_2SO_4 \times 98$ g = **196 t**.
iii. Each S uses 1 O_2 + ½ O_2 = 1.5 O_2: 3.0×10^6 mol × 32 g = **96 t**; volume = $3.0 \times 10^6 \times 22.4$ L = 6.72×10^7 L = **6.72×10^4 m^3**.

MARKING SCHEME

- ✓ The three equations.
- ✓ 2.0×10^6 mol of sulphur.
- ✓ 196 t of H_2SO_4.
- ✓ 96 t (6.72×10^4 m^3) of oxygen.

b. ANSWER A · 4

i. N = 15% of 50 kg = **7.5 kg**.
ii. P_2O_5 = 7.5 kg; P = 7.5 × 62 ÷ 142 = **3.27 kg**. K_2O = 7.5 kg; K = 7.5 × 78 ÷ 94 = **6.22 kg**.
iii. Urea has 28 ÷ 60 = 46.7% N: 7.5 ÷ 0.467 = **16.1 kg** of urea.

MARKING SCHEME

- ✓ 7.5 kg of nitrogen.
- ✓ 3.27 kg of phosphorus.
- ✓ 6.22 kg of potassium.
- ✓ 16.1 kg of urea.

7 Think

ANSWER

In both, fewer volumes of gas form (4 → 2 and 3 → 2), so high pressure shifts the equilibrium forward. In the contact process the conversion of SO_2 to SO_3 is already over 99.5% at 1–2 atm, so more pressure would gain almost nothing, while it would cost a great deal in energy and in equipment that resists the

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

corrosive gas. In Haber's process only about 15% of the gas becomes ammonia in a pass even at 200 atm, so the high pressure is needed for a worthwhile yield and rate, and is worth its cost.

MARKING SCHEME

- ✓ Both reactions reduce the volume of gas, so pressure favors the products.
- ✓ Contact: conversion already over 99% at 1–2 atm; high pressure costs energy and corrosion-proof equipment for little gain.
- ✓ Haber: the yield is low (about 15% a pass), so high pressure is needed.

8 Activity: Sacks in the shop

(not marked)

WHAT STUDENTS SHOULD FIND

Typical sacks: urea (46% N), DAP, $(NH_4)_2HPO_4$ (nitrogen and phosphorus), and potash, KCl (potassium). Urea gives the most nitrogen per kilogram. It absorbs moisture and is very soluble, so it is kept in sealed bags in a dry place, and worked into the soil (or applied before irrigation), since on a moist surface it turns to ammonia that escapes into the air.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	10	13	8	3	**34**

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking