

KCSE ONLINE REVISION

SALTS

www.kcse-online.info

INTRODUCTION TO SALTS

1.(a) A salt is an ionic compound formed when the cation from a base combine with the anion derived from an acid.

A salt is therefore formed when the hydrogen ions in an acid are replaced wholly/fully or partially/partly ,directly or indirectly by a metal or ammonium radical.

(b) The number of ionizable/replaceable hydrogen in an acid is called **basicity** of an acid.

Some acids are therefore:

(i) **monobasic** acids generally denoted **HX** e.g.
HCl, HNO₃, HCOOH, CH₃COOH.

(ii) **dibasic** acids ; generally denoted **H₂X** e.g.
H₂SO₄, H₂SO₃, H₂CO₃, HOOCOOH.

(iii) **tribasic** acids ; generally denoted **H₃X** e.g.
H₃PO₄.

(c) Some salts are **normal** salts while other are **acid** salts.

(i) A normal salt is formed when all the ionizable /replaceable hydrogen in an acid is replaced by a metal or metallic /ammonium radical.

(ii) An acid salt is formed when part/portion the ionizable /replaceable hydrogen in an acid is replaced by a metal or metallic /ammonium radical.

Table showing normal and acid salts derived from common acids

Acid name	Chemical formula	Basicity	Normal salt	Acid salt
Hydrochloric acid	HCl	Monobasic	Chloride(Cl ⁻)	None
Nitric(V)acid	HNO ₃	Monobasic	Nitrate(V)(NO ₃ ⁻)	None
Nitric(III)acid	HNO ₂	Monobasic	Nitrate(III)(NO ₂ ⁻)	None
Sulphuric(VI)acid	H ₂ SO ₄	Dibasic	Sulphate(VI) (SO ₄ ²⁻)	Hydrogen sulphate(VI) (HSO ₄ ⁻)

Sulphuric(IV)acid	H_2SO_3	Dibasic	Sulphate(IV) (SO_3^{2-})	Hydrogen sulphate(IV) (HSO_3^-)
-------------------	-------------------------	---------	-------------------------------------	--

www.kcse-online.info

Carbonic(IV)acid	H ₂ CO ₃	Dibasic	Carbonate(IV)(CO ₃ ²⁻)	Hydrogen carbonate(IV) (HCO ₃ ⁻)
Phosphoric(V) acid	H ₃ PO ₄	Tribasic	Phosphate(V)(PO ₄ ³⁻)	Dihydrogen phosphate(V) (H ₂ PO ₄ ²⁻) Hydrogen diphosphate(V) (HP ₂ O ₄ ²⁻)

The table below show shows some examples of salts.

Base/alkali	Cation	Acid	Anion	Salt	Chemical name of salts
NaOH	Na ⁺	HCl	Cl ⁻	NaCl	Sodium(I)chloride
Mg(OH) ₂	Mg ²⁺	H ₂ SO ₄	SO ₄ ²⁻	MgSO ₄ Mg(HSO ₄) ₂	Magnesium sulphate(VI) Magnesium hydrogen sulphate(VI)
Pb(OH) ₂	Pb ²⁺	HNO ₃	NO ₃ ⁻	Pb(NO ₃) ₂	Lead(II)nitrate(V)
Ba(OH) ₂	Ba ²⁺	HNO ₃	NO ₃ ⁻	Ba(NO ₃) ₂	Barium(II)nitrate(V)
Ca(OH) ₂	Ba ²⁺	H ₂ SO ₄	SO ₄ ²⁻	MgSO ₄	Calcium sulphate(VI)
NH ₄ OH	NH ₄ ⁺	H ₃ PO ₄	PO ₄ ³⁻	(NH ₄) ₃ PO ₄ (NH ₄) ₂ HPO ₄ NH ₄ H ₂ PO ₄	Ammonium phosphate(V) Diammonium phosphate(V) Ammonium diphosphate(V)
KOH	K ⁺	H ₃ PO ₄	PO ₄ ³⁻	K ₃ PO ₄	Potassium phosphate(V)
Al(OH) ₃	Al ³⁺	H ₂ SO ₄	SO ₄ ²⁻	Al ₂ (SO ₄) ₂	Aluminium(III)sulphate(VI)
Fe(OH) ₂	Fe ²⁺	H ₂ SO ₄	SO ₄ ²⁻	FeSO ₄	Iron(II)sulphate(VI)
Fe(OH) ₃	Fe ³⁺	H ₂ SO ₄	SO ₄ ²⁻	Fe ₂ (SO ₄) ₂	Iron(III)sulphate(VI)

(d) Some salts undergo **hygroscopy**, **deliquescence** and **efflorescence**.

(i) Hygroscopic salts /compounds are those that absorb water from the atmosphere but do not form a solution.

Some salts which are hygroscopic include anhydrous copper(II)sulphate(VI), anhydrous cobalt(II)chloride, potassium nitrate(V) common table salt.

(ii)Deliquescent salts /compounds are those that absorb water from the atmosphere and form a solution.

Some salts which are deliquescent include: Sodium nitrate(V),Calcium chloride, Sodium hydroxide, Iron(II)chloride, Magnesium chloride.

(iii)Efflorescent salts/compounds are those that lose their water of crystallization to the atmosphere.

Some salts which effloresces include: sodium carbonate decahydrate, Iron(II)sulphate(VI)heptahydrate, sodium sulphate (VI)decahydrate.

(e)Some salts contain water of crystallization.They are hydrated.Others do not contain water of crystallization. They are anhydrous.

Table showing some hydrated salts.

Name of hydrated salt	Chemical formula
Copper(II)sulphate(VI)pentahydrate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
Aluminium(III)sulphate(VI)hexahydrate	$\text{Al}_2 (\text{SO}_4)_3 \cdot 6\text{H}_2\text{O}$
Zinc(II)sulphate(VI)heptahydrate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
Iron(II)sulphate(VI)heptahydrate	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
Calcium(II)sulphate(VI)heptahydrate	$\text{CaSO}_4 \cdot 7\text{H}_2\text{O}$
Magnesium(II)sulphate(VI)heptahydrate	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
Sodium sulphate(VI)decahydrate	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
Sodium carbonate(IV)decahydrate	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
Potassium carbonate(IV)decahydrate	$\text{K}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
Potassium sulphate(VI)decahydrate	$\text{K}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

(f)Some salts exist as a simple salt while some as complex salts. Below are some complex salts.

Table of some complex salts

Name of complex salt	Chemical formula	Colour of the complex salt
Tetraamminecopper(II)sulphate(VI)	$\text{Cu}(\text{NH}_3)_4 \text{SO}_4 \cdot \text{H}_2\text{O}$	Royal/deep blue solution
Tetraamminezinc(II)nitrate(V)	$\text{Zn}(\text{NH}_3)_4 (\text{NO}_3)_2$	Colourless solution
Tetraamminecopper(II) nitrate(V)	$\text{Cu}(\text{NH}_3)_4 (\text{NO}_3)_2$	Royal/deep blue solution

Tetraamminezinc(II)sulphate(VI)	$Zn(NH_3)_4SO_4$	Colourless solution
---------------------------------	------------------	---------------------

(g)Some salts exist as two salts in one. They are called **double salts**.

Table of some double salts

Name of double salts	Chemical formula
Trona(sodium sesquicarbonate)	$Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$
Ammonium iron(II)sulphate(VI)	$FeSO_4(NH_4)_2SO_4 \cdot 2H_2O$
Ammonium aluminium(III)sulphate(VI)	$Al_2(SO_4)_3(NH_4)_2SO_4 \cdot H_2O$

(h)Some salts dissolve in water to form a **solution**. They are said to be soluble. Others do not dissolve in water. They form a **suspension/precipitate** in water.

Table of solubility of salts

Soluble salts	Insoluble salts
All nitrate(V)salts	
All sulphate(VI)/ SO_4^{2-} salts	except → Barium(II) sulphate(VI)/ $BaSO_4$ Calcium(II) sulphate(VI)/ $CaSO_4$ Lead(II) sulphate(VI)/ $PbSO_4$
All sulphate(IV)/ SO_3^{2-} salts	except → Barium(II) sulphate(IV)/ $BaSO_3$ Calcium(II) sulphate(IV)/ $CaSO_3$ Lead(II) sulphate(IV)/ $PbSO_3$
All chlorides/ Cl^-	except → Silver chloride/ $AgCl$ Lead(II)chloride/ $PbCl_2$ (dissolves in hot water)
All phosphate(V)/ PO_4^{3-}	
All sodium,potassium and ammonium salts	
All hydrogen carbonates/ HCO_3^-	
All hydrogen sulphate(VI)/ HSO_4^-	
Sodium carbonate/ Na_2CO_3 , potassium carbonate/ K_2CO_3 , ammonium carbonate $(NH_4)_2CO_3$	← except All carbonates
All alkalis($KOH,NaOH, NH_4OH$)	← except All bases

13 Salts can be prepared in a school laboratory by a method that uses its solubility in water.

(a) Soluble salts may be prepared by using any of the following methods:

(i) Direct displacement/reaction of a metal with an acid.

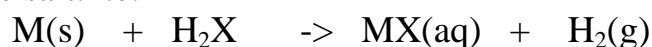
By reacting a metal higher in the reactivity series than hydrogen with a dilute acid, a salt is formed and hydrogen gas is evolved.

Excess of the metal must be used to ensure all the acid has reacted.

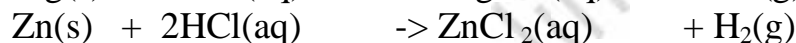
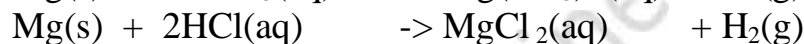
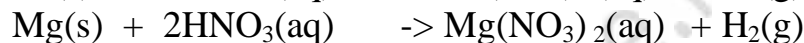
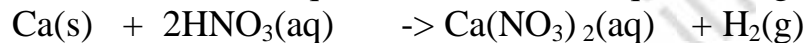
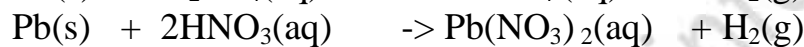
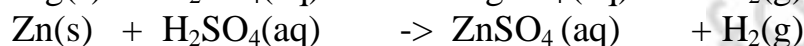
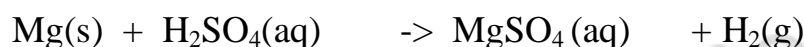
When effervescence/bubbling /fizzing has stopped, excess metal is filtered.

The filtrate is heated to concentrate then allowed to crystallize.

Washing with distilled water then drying between filter papers produces a sample crystal of the salt. i.e.



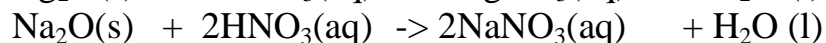
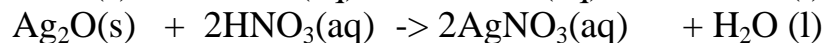
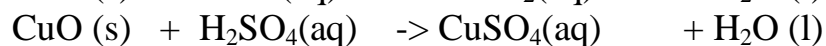
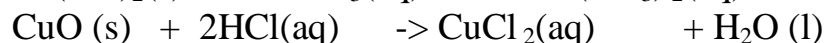
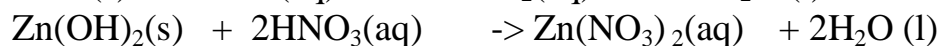
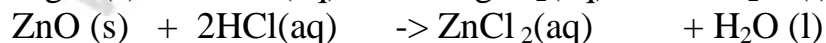
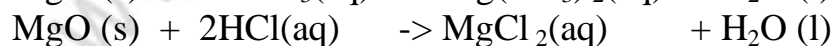
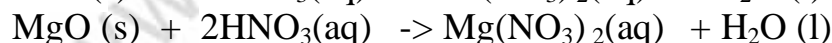
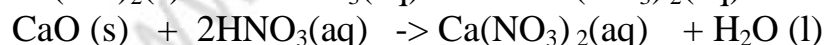
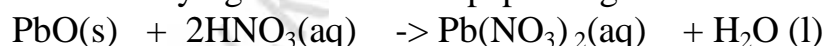
Examples



(ii) Reaction of an insoluble base with an acid

By adding an insoluble base (oxide/hydroxide) to a dilute acid until **no more dissolves**, in the acid, a salt and water are formed. Excess of the base is filtered off.

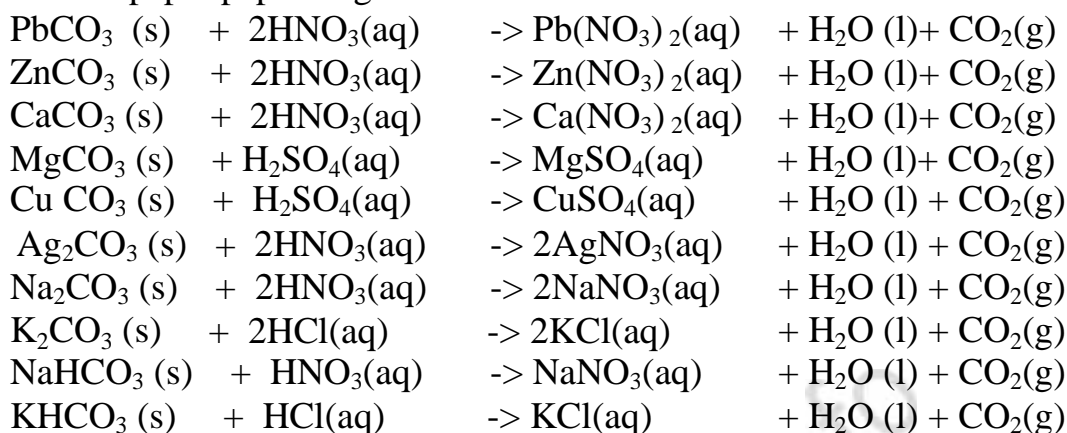
The filtrate is heated to concentrate, allowed to crystallize then washed with distilled water before drying between filter papers e.g.



(iii) reaction of insoluble /soluble carbonate /hydrogen carbonate with an acid.

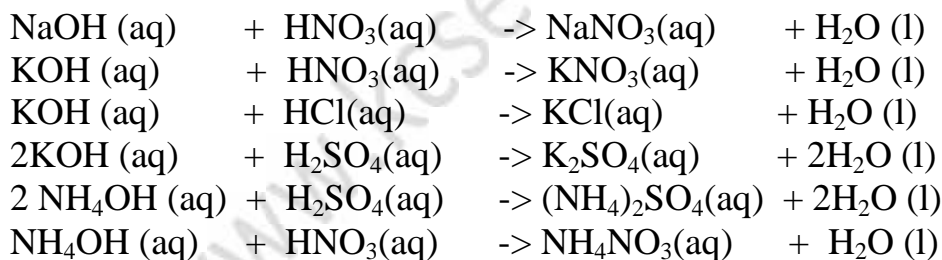
By adding an excess of a soluble /insoluble carbonate or hydrogen carbonate to a dilute acid, effervescence /fizzing/bubbling out of carbon(IV)oxide gas shows the reaction is taking place. When effervescence /fizzing/bubbling out of the gas is

over, excess of the insoluble carbonate is filtered off. The filtrate is heated to concentrate, allowed to crystallize then washed with distilled water before drying between filter papers e.g.



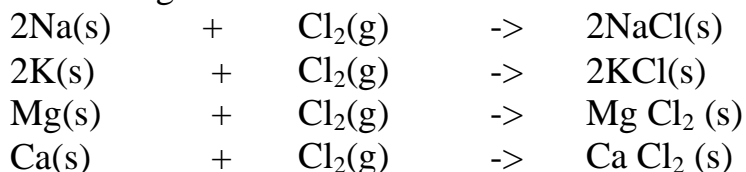
(iv) neutralization/reaction of soluble base/alkali with dilute acid

By adding an acid to a burette into a known volume of an alkali with 2-3 drops of an indicator, the colour of the indicator changes when the acid has completely reacted with an alkali at the **end point**. The procedure is then repeated without the indicator. The solution mixture is then heated to concentrate, allowed to crystallize, washed with distilled water before drying with filter papers. e.g.



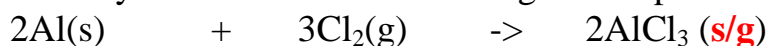
(iv) direct synthesis/combination.

When a metal **burns** in a gas jar containing a non metal, the two directly combine to form a salt. e.g.

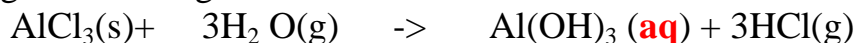


Some salts once formed undergo **sublimation** and **hydrolysis**. Care should be taken to avoid water/moisture into the reaction flask during their preparation. Such salts include aluminium(III)chloride(AlCl_3) and iron (III)chloride(FeCl_3)

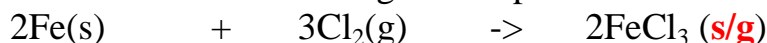
1. Heated aluminium foil reacts with chlorine to form aluminium(III)chloride that sublimes away from the source of heating then deposited as solid again



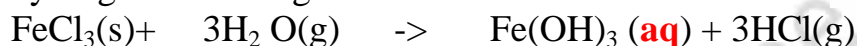
Once formed aluminium(III)chloride hydrolyses/reacts with water vapour / moisture present to form aluminium hydroxide solution and highly acidic fumes of hydrogen chloride gas.



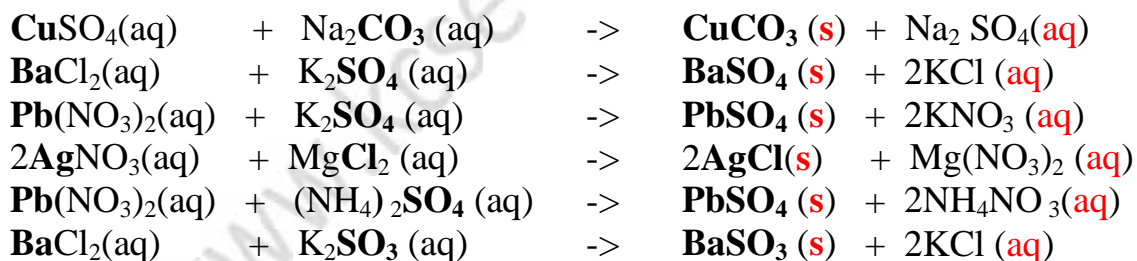
2. Heated iron filings reacts with chlorine to form iron(III)chloride that sublimes away from the source of heating then deposited as solid again



Once formed , aluminium(III)chloride hydrolyses/reacts with water vapour / moisture present to form aluminium hydroxide solution and highly acidic fumes of hydrogen chloride gas.



(b)**Insoluble** salts can be prepared by reacting **two** suitable **soluble** salts to form **one soluble** and **one insoluble**. This is called **double decomposition** or **precipitation**. The mixture is filtered and the **residue** is washed with distilled water then dried.

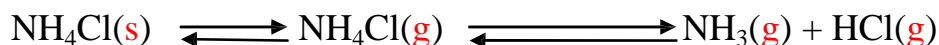


14. Salts may lose their water of crystallization , decompose ,melt or sublime on heating on a Bunsen burner flame.

The following shows the behavior of some salts on heating gently /or strongly in a laboratory school burner:

(a)effect of heat on chlorides

All chlorides have very high melting and boiling points and therefore are not affected by laboratory heating except ammonium chloride. Ammonium chloride **sublimes** on **gentle** heating. It **dissociate** into the constituent **ammonia** and **hydrogen chloride** gases on strong heating.

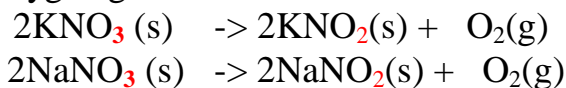


(sublimation)

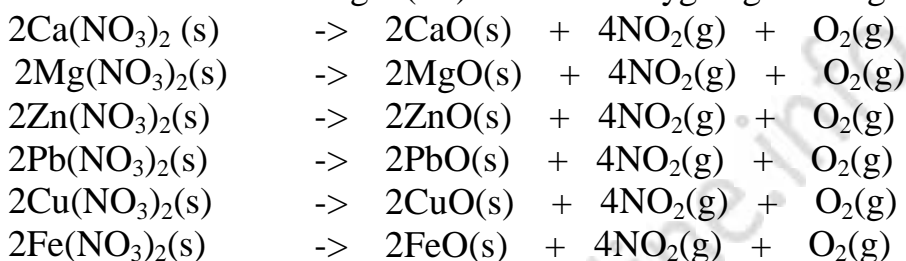
(dissociation)

(b) effect of heat on nitrate(V)

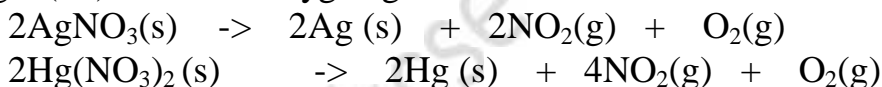
(i) Potassium nitrate(V)/KNO₃ and sodium nitrate(V)/NaNO₃ decompose on heating to form Potassium nitrate(III)/KNO₂ and sodium nitrate(III)/NaNO₂ and producing Oxygen gas in each case.



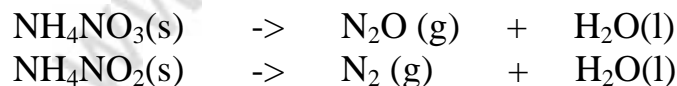
(ii) Heavy metal nitrates(V) salts decompose on heating to form the oxide and a mixture of brown acidic nitrogen(IV)oxide and oxygen gases. e.g.



(iii) Silver(I)nitrate(V) and mercury(II) nitrate(V) are lowest in the reactivity series. They decompose on heating to form the **metal**(silver and mercury)and the Nitrogen(IV)oxide and oxygen gas. i.e.

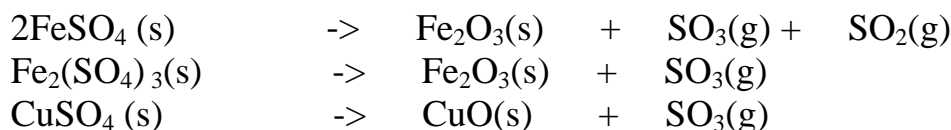


(iv) Ammonium nitrate(V) and Ammonium nitrate(III) decompose on heating to Nitrogen(I)oxide(relights/rekindles glowing splint) and nitrogen gas respectively. Water is also formed.i.e.



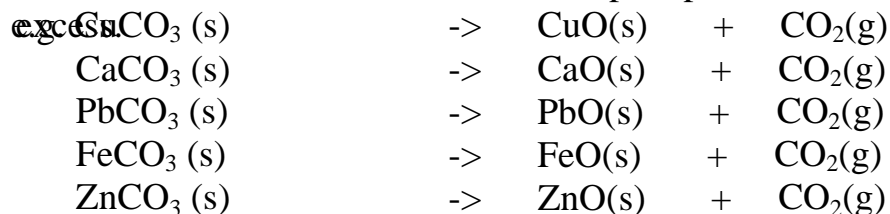
(c) effect of heat on nitrate(V)

Only Iron(II)sulphate(VI), Iron(III)sulphate(VI) and copper(II)sulphate(VI) decompose on heating. They form the **oxide**, and produce highly acidic fumes of acidic **sulphur(IV)oxide** gas.

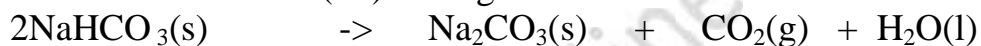


(d) effect of heat on carbonates(IV) and hydrogen carbonate(IV). (i) Sodium carbonate(IV) and potassium carbonate(IV) do not decompose on heating.

(ii) Heavy metal nitrate(IV) salts decompose on heating to form the oxide and produce carbon(IV)oxide gas. Carbon (IV)oxide gas forms a white precipitate when bubbled in lime water. The white precipitate dissolves if the gas is in



(iii) Sodium hydrogen carbonate(IV) and Potassium hydrogen carbonate(IV) decompose on heating to give the corresponding carbonate (IV) and form water and carbon(IV)oxide gas. i.e.



(iii) Calcium hydrogen carbonate (IV) and Magnesium hydrogen carbonate(IV) decompose on heating to give the corresponding carbonate (IV) and form water and carbon(IV)oxide gas. i. e.

