Chemistry · Transition Elements

Properties of Iron

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Multiple choice questions — 71 questions

1 Each of the following is a physical property of iron, except .....

(A) It conducts electricity less than copper.

(B) It is easy to shape, like copper.

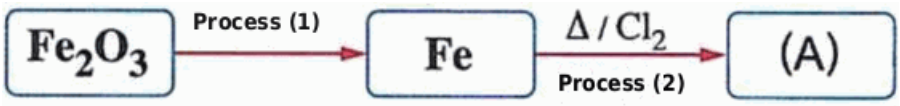
(C) It is denser than manganese.

(D) Its magnetic properties are like those of zinc.

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2 From the following chart:

Which of the following gives (1), (2) and (A)?



(A) (1): reduction , (2): oxidation , (A): $FeCl_3$

(B) (1): oxidation , (2): reduction , (A): $FeCl_2$

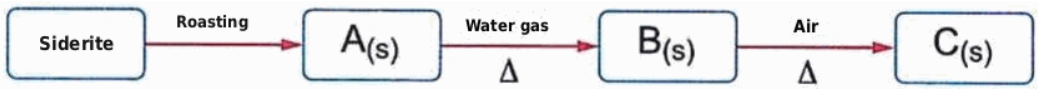
(C) (1): reduction , (2): oxidation , (A): $FeCl_2$

(D) (1): oxidation , (2): reduction , (A): $FeCl_3$

---

3 From the following chart:

Which of the following is correct?



(A) (A): black , (B): Fe_2O_3

(B) (B): Fe , (C): Fe_3O_4

(C) (A): red , (C): FeO

(D) (A): FeO , (B): Fe

---

4 Hydrogen gas is given off when iron reacts with .....

(A) steam (at 500°C).

(B) concentrated sulphuric acid (at 400°C).

(C) steam (at 100°C).

(D) concentrated nitric acid (at 200°C).

---

5 The metal used as a catalyst in preparing ammonia gas reacts with air under suitable conditions, forming a compound whose chemical formula is .....

(A) FeO (B) MnO_2 (C) Fe_3O_4 (D) Mn_2O_3

6 How many moles of sulphur are needed to react completely with 4 mol of iron?

(A) 2 mol (B) 4 mol (C) 6 mol (D) 8 mol

7 The compound FeS agrees with the compound .....

(A) Cu_2Cl_2 in magnetic properties.

(B) ZnO in the possibility of being oxidized.

(C) $FeCl_3$ in the possibility of preparing it directly from iron.

(D) $KMnO_4$ in the possibility of using it as a strong oxidizing agent.

8 The salt produced from the reaction of iron with dilute hydrochloric acid agrees with the salt produced from the reaction of iron with dilute sulphuric acid in each of the following, except that they .....

(A) are paramagnetic substances. (B) are iron(II) salts.

(C) contain the same number of anions. (D) dissolve in water.

9 When iron reacts with substance (1) or with substance (2) under the same reaction conditions, substance (3) is formed.

Which of the following is correct?

(A) (1): air , (2): steam , (3): magnetic iron oxide.

(B) (1): chlorine , (2): hydrochloric acid , (3): iron(II) chloride.

(C) (1): oxygen , (2): carbon dioxide , (3): iron(III) oxide.

(D) (1): steam , (2): ammonium hydroxide , (3): magnetic iron oxide.

10 Each of the following is a property of iron, except that it .....

(A) does not react with dry air at ordinary temperatures.

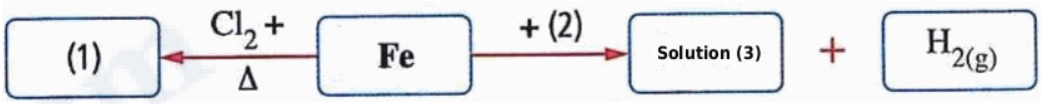
(B) does not react with hot concentrated sulphuric acid.

(C) reacts with chlorine gas forming a salt that cannot be oxidized.

(D) reacts with dilute HCl forming a salt that is easily oxidized.

11 The following chart shows some chemical reactions:

Each of the following is correct, except .....



(A) The oxidation number of the cation of compound (1) is +3

(B) The oxidation number of the cation of compound (3) is +2

(C) Compound (3) is easily oxidized.

(D) Compound (2) is concentrated nitric acid.

---

12 The products of the reaction of iron with dilute and with concentrated acid (X) are different.

What is acid (X), and what is the common product of the two reactions?

(A) Sulphuric acid / SO_2 gas is given off

(B) Sulphuric acid / Fe^{2+} ions are formed

(C) Nitric acid / steam is given off.

(D) Nitric acid / Fe^{3+} ions are formed

---

13 From the following oxidation-reduction reactions:

(1): the combustion of coke in the blast furnace.

(2): the reaction of iron(III) oxide with water gas.

(3): the reaction of iron with dilute hydrochloric acid.

What is the substance acting as the oxidizing agent in each of the previous reactions?

(A) (1): C , (2): Fe^{3+} , (3): H^+

(B) (1): C , (2): $CO + H_2$, (3): Fe

(C) (1): O_2 , (2): Fe^{3+} , (3): Fe

(D) (1): O_2 , (2): Fe^{3+} , (3): H^+

---

14 Which of the following is correct when iron reacts with .....

(A) dilute or hot concentrated sulphuric acid, forming iron(III) sulphate.

(B) the elements sulphur or chlorine, forming the two iron(II) compounds.

(C) steam or oxygen (at 500°C), forming a strong magnet.

(D) dilute or concentrated nitric acid, forming iron(III) nitrate.

---

15 Four equal volumes of different acids were added to four identical pieces of iron (each one separately).

Which acid forms a layer of oxide as the final product of the reaction?

(A) Dilute sulphuric acid.

(B) Concentrated sulphuric acid.

(C) Dilute hydrochloric acid.

(D) Concentrated nitric acid.

16 A piece of iron was dipped in acid (X) for some time. When it was washed with distilled water and moved to a beaker containing dilute HCl solution, gas bubbles were given off after some time.

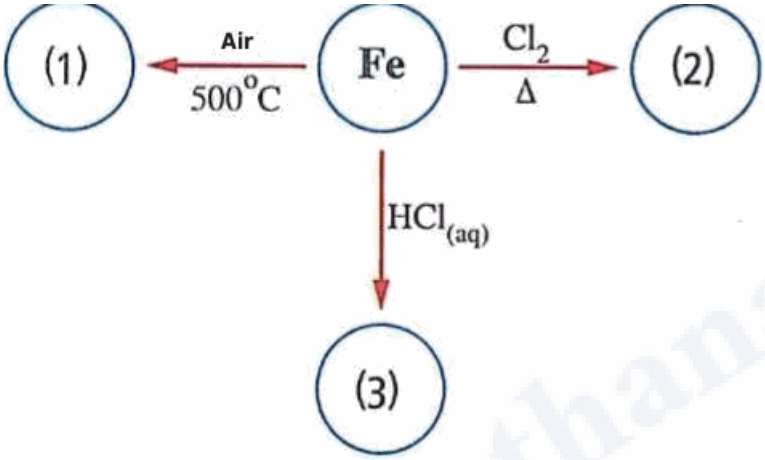
What is acid (X)?

(A) Dilute sulphuric acid.
(B) Hot concentrated sulphuric acid.
(C) Dilute hydrochloric acid.
(D) Concentrated nitric acid.

---

17 From the opposite chart:

Which of the following is correct?



(A) (1): FeO , (2): $FeCl_3$, (3): $FeCl_2$
(B) (1): Fe_3O_4 , (2): $FeCl_2$, (3): $FeCl_3$
(C) (1): Fe_3O_4 , (2): $FeCl_3$, (3): $FeCl_2$
(D) (1): FeO , (2): $FeCl_2$, (3): $FeCl_3$

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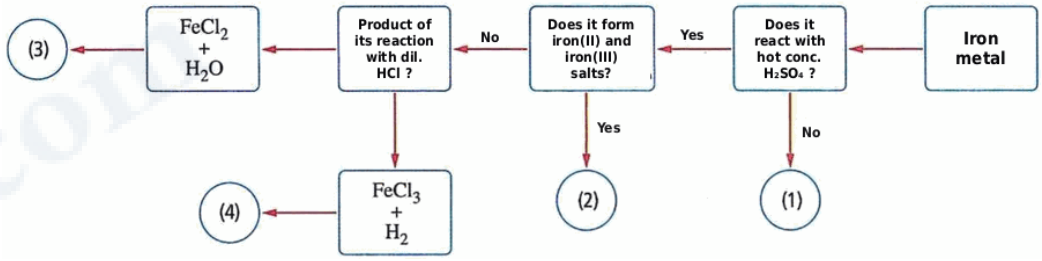
18 What processes are carried out, in order, to obtain iron(III) chloride from siderite ore?

(A) Roasting – reduction at 800°C – oxidation.
(B) Oxidation – reduction at 800°C – roasting.
(C) Heating – reduction at 300°C – oxidation.
(D) Reduction at 300°C – oxidation – heating at 800°C

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19 From the following chart:

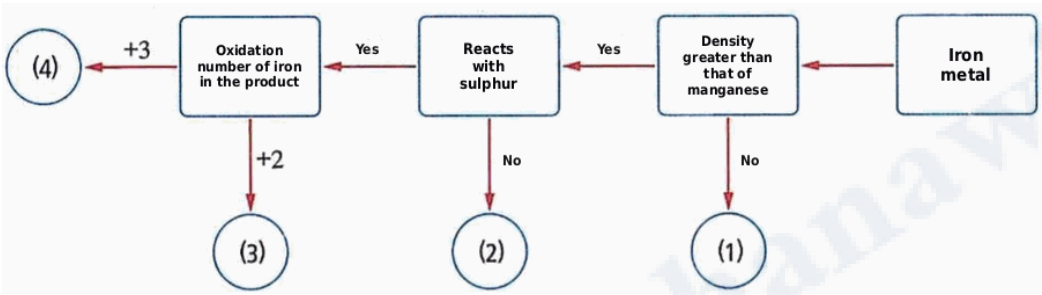
Which of the following represents iron metal?



(A) (1). (B) (2). (C) (3). (D) (4).

20 From the following chart:

Which of the following represents iron metal?



(A) (1). (B) (2). (C) (3). (D) (4).

21 When iron(II) oxalate is heated in air, ... is produced.

(A) FeO , CO only
(B) Fe_2O_3 , CO_2
(C) FeO , CO , CO_2
(D) Fe_3O_4 , CO_2 , CO

22 To change limonite into iron(II) oxide, ... is needed.

(A) roasting then oxidation
(B) roasting then reduction at 600°C
(C) reduction then oxidation
(D) oxidation then reduction at 800°C

23 The mass of the solid product is less than the mass of the solid reactant in each of the following, except .....

(A) heating iron(II) oxalate away from air.
(B) heating iron(II) carbonate away from air.
(C) heating iron to redness in air.
(D) reducing iron(III) oxide at a temperature higher than 700°C

24 When acidified $KMnO_4$ reacts with $FeSO_4$ .....

(A) $FeSO_4$ only is oxidized.

(B) $KMnO_4$ only is oxidized.

(C) $FeSO_4$ is oxidized and $KMnO_4$ is reduced.

(D) no oxidation or reduction takes place.

---

25 The iron oxide produced from the thermal decomposition of siderite is characterized by each of the following, except .....

(A) The cation of the oxide is easily oxidized.

(B) It is formed by roasting the compound (FeC_2O_4).

(C) It is formed by passing hydrogen gas over red iron oxide at 650°C

(D) It reacts with dilute acids forming a solution that is easily oxidized.

---

26 Each of the following is a property of the compound FeO, except that it .....

(A) changes colour when exposed to hot air.

(B) dissolves in acids forming iron(II) salts.

(C) is a basic oxide that reacts with dilute acids.

(D) is easily reduced at room temperature.

---

27 Iron oxide (X) is produced by reducing the iron oxide that is higher than it in oxidation state with hydrogen at 500°C

Which of the following describes oxide (X)?

(A) Diamagnetic.

(B) It is the main charge in the oxygen converter.

(C) It dissolves in $H_2SO_4(aq)$

(D) It is affected by carbon monoxide under ordinary conditions.

---

28 Iron oxide (X) can be completely oxidized to iron oxide (Y).

Which of the following is correct?

(A) Oxidizing 1 mol of oxide (X) forms 1 mol of oxide (Y).

(B) Oxidizing 2 mol of oxide (X) forms 1 mol of oxide (Y).

(C) Oxide (Y) can be reduced or oxidized.

(D) Oxide (X) can be reduced to the mixed iron oxide.

---

29 The following equations show some reactions of metal (R) and its oxide RO:

- $3R(s) + 2O_2(g) \longrightarrow^{(\Delta)} R_3O_4(s)$
- $R(s) + 2HCl(aq) \longrightarrow RCl_2(aq) + H_2(g)$
- $RO(s) + 2HCl(aq) \longrightarrow RCl_2(aq) + H_2O(l)$

Element (R) is probably .....

(A) scandium. (B) copper. (C) iron. (D) zinc.

---

30 Which salt has its iron cation oxidized when it is strongly heated away from air?

(A) Iron(II) oxalate. (B) Iron(II) sulphate.

(C) Iron(II) carbonate. (D) Iron(III) hydroxide.

---

31 Each of the following is a method of preparing a red oxide, except .....

(A) oxidizing the black iron oxide compound.

(B) the reaction of iron heated to redness with air.

(C) heating iron(II) oxalate in air.

(D) the thermal decomposition of iron(III) hydroxide.

---

32 From the following statements:

(1): it is produced by heating FeC_2O_4 in air.

(2): it is produced by reducing Fe_2O_3 with H_2

(3): it reacts with oxygen forming Fe_3O_4

(4): it reacts with dilute acids forming an iron(II) salt.

Which of the previous statements describe iron(II) oxide?

(A) (1) , (2). (B) (1) , (4). (C) (2) , (3). (D) (2) , (4).

---

33 Iron(III) oxide is formed by strongly heating salt (X).
What are the hydrated ions formed when salt (X) dissolves in water?

(A) Fe^{2+} , SO_4^{2-} (B) Fe^{2+} , SO_4^{3-} (C) Fe^{3+} , SO_4^{3-} (D) Fe^{3+} , SO_4^{2-}

34 Each of the following produces a black substance, except .....

(A) heating iron to redness in air.
(B) heating siderite away from air.
(C) passing $H_2(g)$ over haematite at 550°C
(D) strongly heating iron(II) sulphate.

35 Which of the following is a thermal decomposition reaction and an oxidation-reduction reaction?

(A) Heating iron in atmospheric air.
(B) Heating iron(II) carbonate in the absence of air.
(C) Heating iron(II) sulphate.
(D) Heating iron(III) hydroxide.

36 What gases or vapours may be formed when iron(II) sulphate is changed into iron?

(A) SO_2 , SO_3 only.
(B) SO_2 , CO_2 only.
(C) SO_2 , SO_3 , H_2O , CO_2
(D) SO_2 , SO_3 , H_2O , CO

37 Changing iron(III) hydroxide into iron(II) oxide includes the two processes of .....

(A) oxidation then reduction.
(B) thermal decomposition then reduction.
(C) reduction then simple displacement.
(D) thermal decomposition then oxidation.

38 Metal (M) is part of the chemical composition of the yellow hydrated ore (X).
Each of the following is correct, except .....

(A) Metal (M) reacts with hot concentrated sulphuric acid, but concentrated nitric acid makes it apparently passive.
(B) Metal (M) is used as a catalyst in the industrial preparation of ammonia.
(C) Ore (X) decomposes by heat forming FeO , SO_2 , SO_3
(D) Ore (X) is used to obtain metal (M).

39 A student recorded the following observations on a chemical reaction:

- No gas was given off.
- A colour change took place.
- No precipitate was formed.

What are the reactants used in this reaction?

(A) Iron(III) chloride , ammonium hydroxide.

(B) Iron(II) oxide , dilute sulphuric acid.

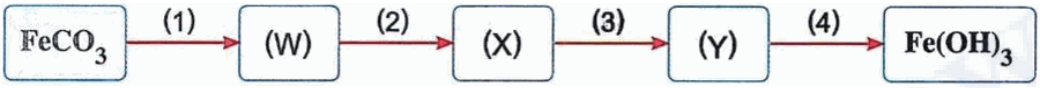
(C) Iron , steam (at 500°C).

(D) Iron , dilute sulphuric acid.

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40 In the following series of reactions:

Which of the following is correct?



(A) (1): a thermal decomposition reaction , (3): dilute hydrochloric acid.

(B) (2): an oxidation reaction , (4): sodium hydroxide.

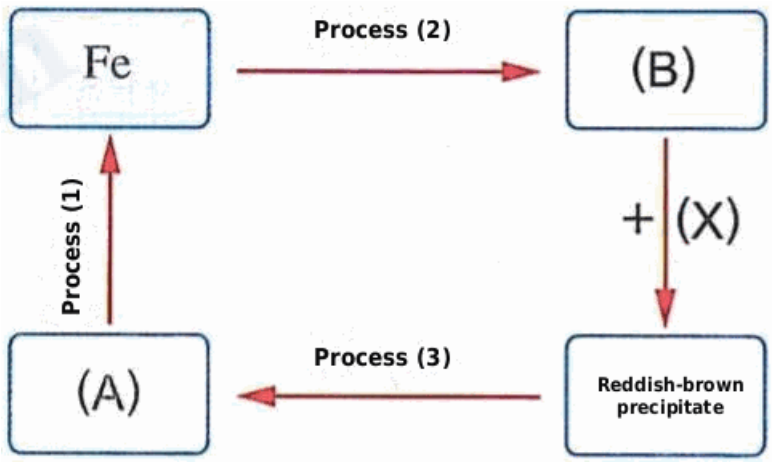
(C) (1): an oxidation reaction , (4): sodium hydroxide.

(D) (2): a reduction reaction , (3): concentrated sulphuric acid.

---

41 From the opposite chart:

Which of the following is correct?



(A) Process (1): oxidation , process (2): reduction , substance (X): NaOH(aq) , process (3): displacement

(B) Process (1): reduction , process (2): oxidation , substance (X): $H_2O(l)$, process (3): thermal decomposition

(C) Process (1): oxidation , process (2): reduction , substance (X): $H_2O(l)$, process (3): displacement

(D) Process (1): reduction , process (2): oxidation , substance (X): NaOH(aq) , process (3): thermal decomposition

---

42 Which of the following is correct for the iron compound used as a red colour in paints?

(A) The oxidation number of iron in this compound is +2

(B) It is reduced by CO at a temperature higher than 700°C, forming iron.

(C) The mass of iron in it increases when it is roasted.

(D) It can be obtained from the reaction of FeO with dilute H_2SO_4.

---

43 Each of the following applies to iron(III) oxide, except that it .....

(A) is paramagnetic.

(B) is the product of roasting siderite.

(C) dissolves in dilute HCl.

(D) is a basic oxide.

---

44 The opposite figure shows a rock of the Earth's crust that contains one of the iron ores.
What is the chemical equation that shows one of the reactions of the main chemical compound in this ore?



(A) $Fe_3O_4(s) + H_2(g) \longrightarrow^{(400:700°C)} 3FeO(s) + H_2O(v)$

(B) $4FeO(s) + O_2(g) \longrightarrow^{(\Delta)} 2Fe_2O_3(s)$

(C) $Fe_2O_3(s) + 3H_2SO_4(l\ ,\ conc) \longrightarrow^{(\Delta)} Fe_2(SO_4)_3(aq) + 3H_2O(v)$

(D) $FeO(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2O(l)$

---

45 What processes are used to change magnetic iron oxide into iron(III) chloride?

(A) Reduction → oxidation → neutralization.

(B) Oxidation → oxidation → neutralization.

(C) Oxidation → neutralization → reduction.

(D) Neutralization → reduction → oxidation.

---

46 1 mol of SO_3 gas reacts with 1 mol of iron oxide (X), forming only 1 mol of salt (Y) as the product of the reaction, which decomposes by heat forming iron(III) oxide.
What are the chemical formulas of oxide (X) and salt (Y)?

(A) Oxide (X): Fe_2O_3 , salt (Y): $Fe_2(SO_4)_3$

(B) Oxide (X): FeO , salt (Y): $FeSO_4$

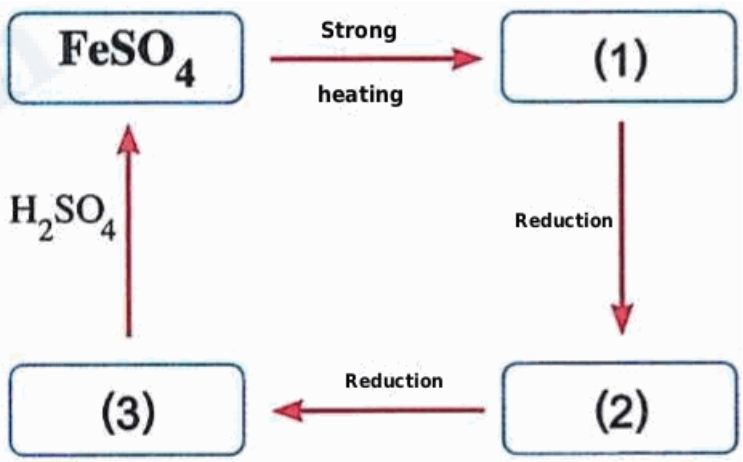
(C) Oxide (X): Fe_2O_3 , salt (Y): $FeSO_4$

(D) Oxide (X): FeO , salt (Y): $Fe_2(SO_4)_3$

---

47 From the opposite chart:

Which of the following is correct?



(A) (1): Fe_2O_3 , (2): FeO , (3): Fe_3O_4

(B) (1): Fe_2O_3 , (2): Fe_3O_4 , (3): FeO

(C) (1): FeO , (2): Fe_2O_3 , (3): Fe_3O_4

(D) (1): FeO , (2): Fe_3O_4 , (3): Fe_2O_3

48 Changing iron(III) oxide into iron(II) sulphate includes each of the following, except .....

(A) reducing the compound Fe_2O_3, forming a basic oxide.

(B) the reaction of iron(II) oxide with sulphuric acid, forming a salt and water.

(C) using H_2 gas as a reducing agent.

(D) the products of reducing Fe_2O_3 not differing with the reaction temperature.

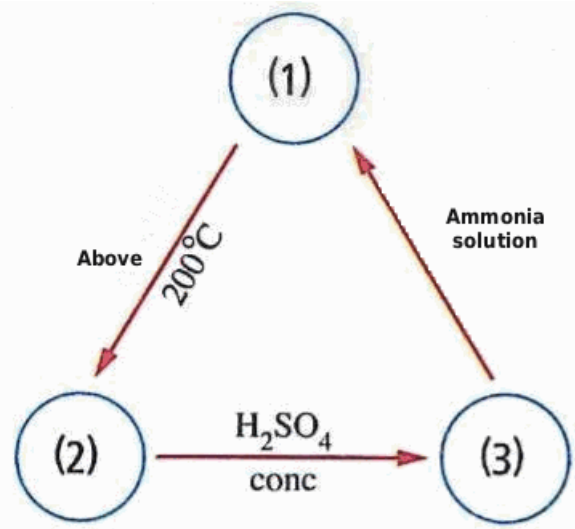
49 Iron(II) sulphate can be changed in practice into an iron(III) chloride solution.

What are the numbers of moles of iron oxide and of the acid used to produce 4 mol of iron(III) chloride solution, respectively?

(A) 2 , 4 (B) 2 , 12 (C) 4 , 6 (D) 2 , 2

50 From the opposite chart:

Which of the following is correct?



(A) (1): iron(III) hydroxide , (2): iron(II) oxide.

(B) (1): iron(II) hydroxide , (3): iron(II) sulphate.

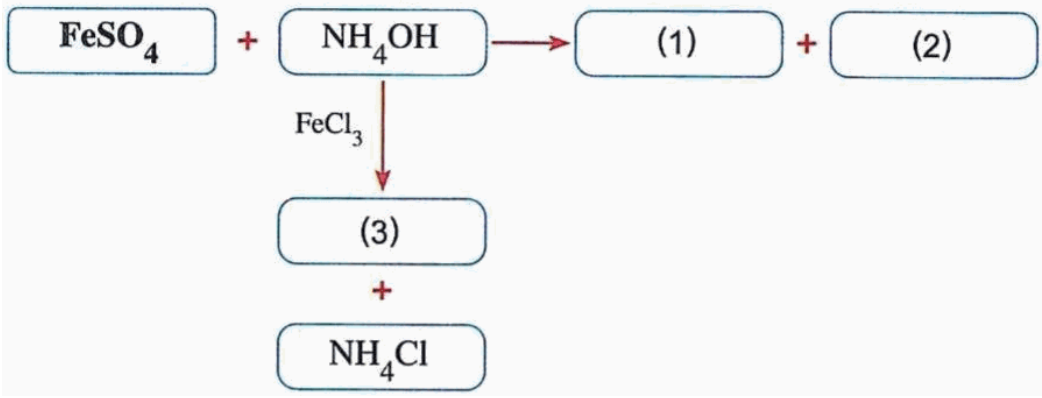
(C) (1): iron(II) hydroxide , (2): iron(III) oxide.

(D) (2): iron(III) oxide , (3): iron(III) sulphate.

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51 The following chart shows some chemical reactions:

Which of the following is correct?



(A) Both compounds (1) and (3) dissolve in water.

(B) Both compounds (2) and (3) dissolve in water.

(C) Compound (1) decomposes on strong heating, forming iron and steam.

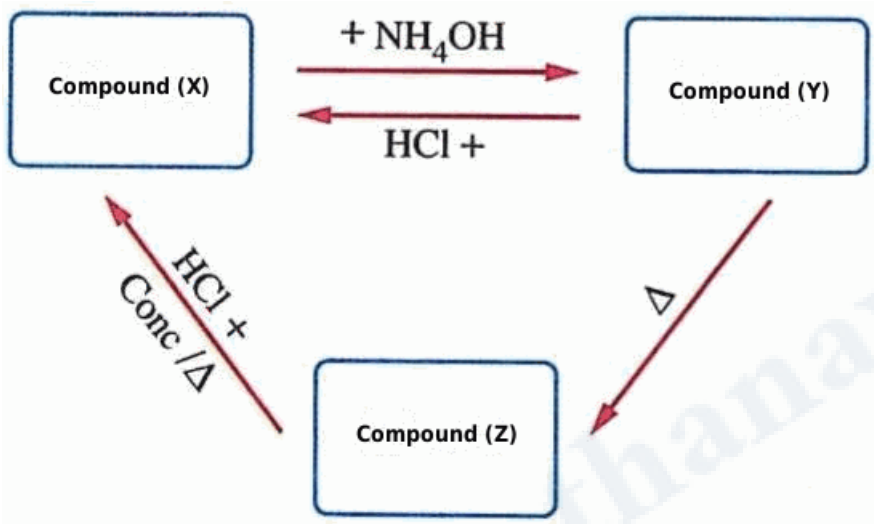
(D) Compound (3) decomposes on strong heating, forming a red powder.

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52 When substance (X) is heated, Fe_2O_3 is formed; when substance (Y) is heated away from air, FeO is formed; and when substance (Z) is heated to 500°C in air, Fe_3O_4 is formed.
Which of the following is correct?

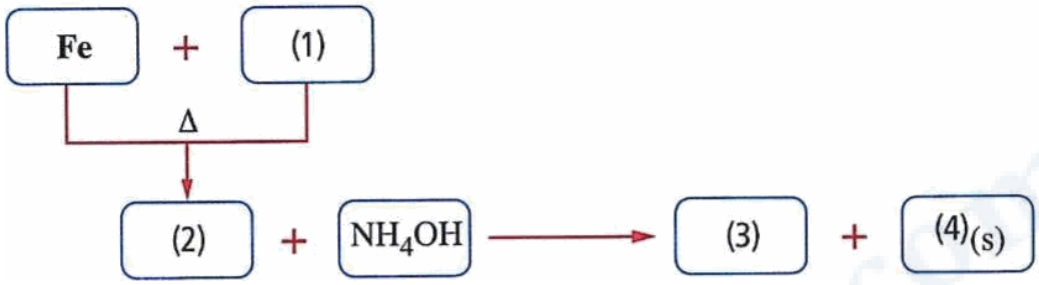
(A) (X): $FeSO_4$, (Y): Fe , (Z): FeC_2O_4
(B) (X): Fe , (Y): FeC_2O_4 , (Z): $FeSO_4$
(C) (X): $FeSO_4$, (Y): FeC_2O_4 , (Z): Fe
(D) (X): FeC_2O_4 , (Y): Fe , (Z): $FeSO_4$

53 The opposite chart includes three types of iron compounds.
Which of the following gives the types of these compounds?



(A) (X): an iron oxide , (Y): an iron hydroxide , (Z): an iron salt.
(B) (X): an iron salt , (Y): an iron oxide , (Z): an iron hydroxide.
(C) (X): an iron hydroxide , (Y): an iron oxide , (Z): an iron salt.
(D) (X): an iron salt , (Y): an iron hydroxide , (Z): an iron oxide.

54 From the following chart:
Which of the following is correct?



(A) (1): HCl , (3): $Fe(OH)_3$
(B) (2): $FeCl_3$, (4): $Fe(OH)_3$
(C) (3): $Fe(OH)_2$, (4): NH_4Cl
(D) (1): Cl_2 , (2): $FeCl_2$

55 When the salt (FeC_2O_4) is heated in air, the solid compound (X) is produced; when (X) is reduced at 270°C, the solid compound (Y) is produced.

Which of the following is correct?

(A) (X): reacts with HCl(aq) , (Y): reacts with H_2SO_4(aq)

(B) (X): reacts with H_2SO_4(l) , (Y): reacts with H_2SO_4(l)

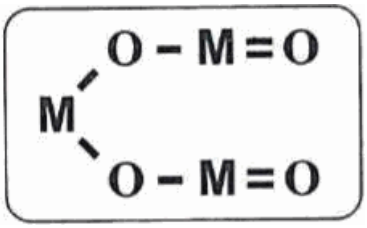
(C) (X): reacts with HCl(aq) , (Y): reacts with H_2SO_4(l)

(D) (X): reacts with H_2SO_4(l) , (Y): reacts with HCl(aq)

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56 From the chemical formula shown in the opposite figure:

What is element (M), and how can it be obtained from the oxide M_2O_3?



(A) Fe , by oxidation.

(B) Fe , by reduction.

(C) Co , by oxidation.

(D) Co , by reduction.

---

57 How many coloured compounds are used and produced in changing iron(III) hydroxide into magnetic iron oxide?

(A) 1 (B) 2 (C) 3 (D) 4

---

58 When iron heated to redness reacts with air, a compound is formed that .....

(A) 1 mol of it is reduced by 4 mol of H_2, forming 1 mol of iron.

(B) 1 mol of it reacts with 8 mol of HCl, forming 2 mol of $FeCl_3$ and water only.

(C) 1 mol of it is reduced by 1 mol of H_2 (at 600°C).

(D) is oxidized to FeO when heated in air.

---

59 Each of the following is correct for one of the iron oxides, except that it .....

(A) is prepared by oxidizing Fe_3O_4

(B) is prepared by heating iron(II) oxalate in air.

(C) reacts with hot concentrated mineral acids forming iron(III) salts and steam.

(D) is prepared by reducing one of the black iron oxides.

60 Each of the following describes the properties of red iron oxide, except that it .....

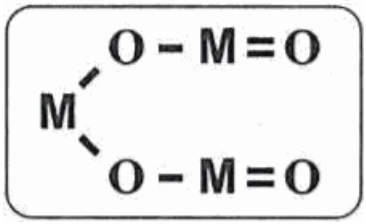
(A) is prepared by heating iron(II) sulphate in air.

(B) reacts with dilute acids forming solutions of iron(III) salts.

(C) forms a black compound when it is reduced.

(D) can be reduced to two types of oxides.

61 Which of the following is produced from the reaction of the opposite oxide with hot concentrated acids?



(A) M^{2+} salts only. (B) M^{3+} salts only. (C) M^{+} , M^{2+} salts (D) M^{2+} , M^{3+} salts

62 When 1 mol of magnetic iron oxide reacts with 8 mol of hot concentrated hydrochloric acid, ... is formed.

(A) 6 mol of products

(B) 5 mol of chloride ions

(C) 2 mol of iron(III) chloride

(D) 3 mol of iron(III) ions

63 Magnetic iron oxide can be changed into a salt solution that forms a reddish-brown precipitate with an alkaline solution by .....

(A) reducing magnetic iron oxide, then reacting the product with dilute HCl.

(B) reducing magnetic iron oxide, then reacting the product with water.

(C) oxidizing magnetic iron oxide, then reacting the product with NaOH solution.

(D) oxidizing magnetic iron oxide, then reacting the product with hot concentrated HCl.

64 The iron oxide prepared by heating iron in air to redness reacts with .....

(A) hot concentrated hydrochloric acid, forming an iron(II) salt and water.

(B) hot concentrated sulphuric acid, forming an iron(III) salt and water.

(C) hot concentrated hydrochloric acid, forming iron(II) and iron(III) salts and water.

(D) hot concentrated sulphuric acid, forming iron(I) and iron(II) salts and water.

65 When 1 mol of one of the two black iron oxides is oxidized in air, ... is formed.

(A) 2 mol of red iron oxide
(B) 0.5 mol of yellow iron oxide
(C) 2 mol of yellow iron oxide
(D) 0.5 mol of red iron oxide

---

66 When a sample of the black iron ore compound (X) is heated in air, it changes into the red iron ore compound (Y).

The ratio between the coefficient of the ore compound (X) and the coefficient of the ore compound (Y) in the balanced equation is .....

(A) (X : 1) : (Y : 2) (B) (X : 2) : (Y : 5) (C) (X : 2) : (Y : 3) (D) (X : 3) : (Y : 4)

---

67 Here are four chemical equations:

(1) $4Ca + W \longrightarrow 4CaO + 3Fe$

(2) $3C + 2Fe_2O_3 \longrightarrow 3CO_2 + X$

(3) $4FeS + 7O_2 \longrightarrow 4SO_2 + 2Y$

(4) $CO + Z \longrightarrow CO_2 + Fe$

Which of the following is correct?

(A) (W): is reduced to Fe_2O_3 , (X): used as a catalyst , (Y): found in haematite ore , (Z): easily oxidized in hot air

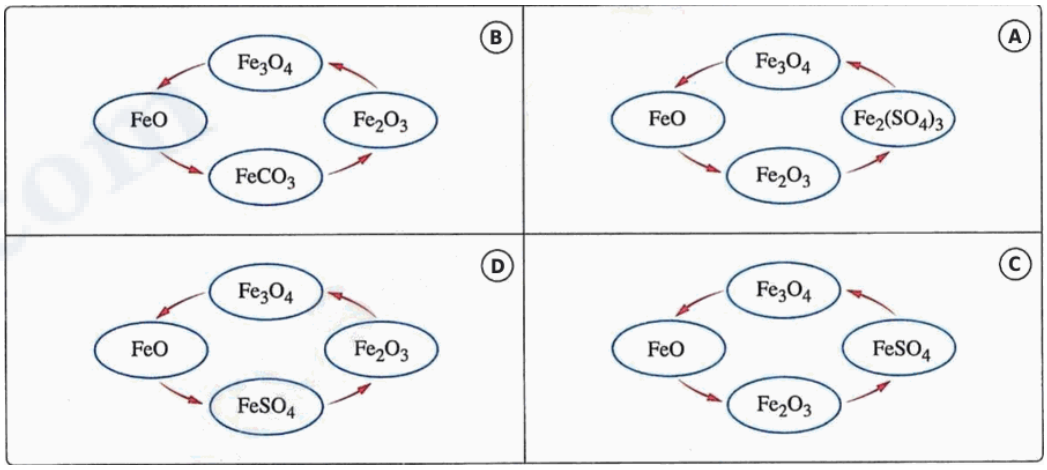
(B) (W): is reduced to Fe_2O_3 , (X): ductile and malleable , (Y): does not dissolve in water , (Z): a compound with magnetic properties

(C) (W): a compound with magnetic properties , (X): the backbone of heavy industries , (Y): a red compound , (Z): a black compound

(D) (W): a compound with magnetic properties , (X): the backbone of heavy industries , (Y): a black compound , (Z): a red compound

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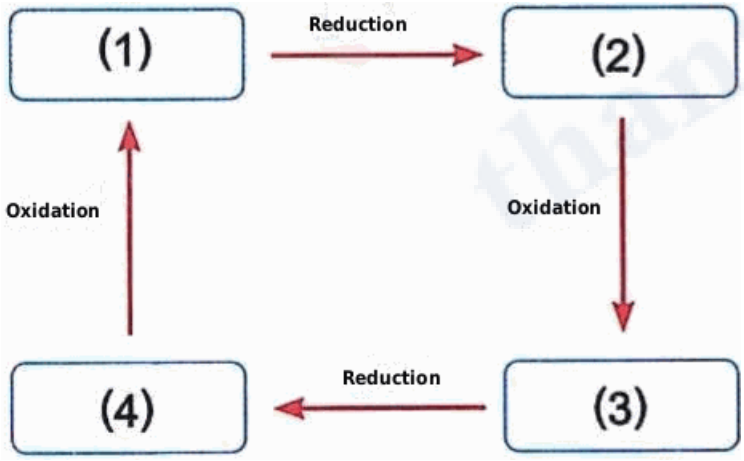
68 The way to obtain magnetic iron oxide from iron(II) oxide is shown by the scheme in .....



(A) Figure (A) (B) Figure (B) (C) Figure (C) (D) Figure (D)

69 From the opposite chart:

Which of the following is correct?



(A) (1): Fe_2O_3 , (2): FeO , (3): Fe_3O_4 , (4): Fe_2O_3

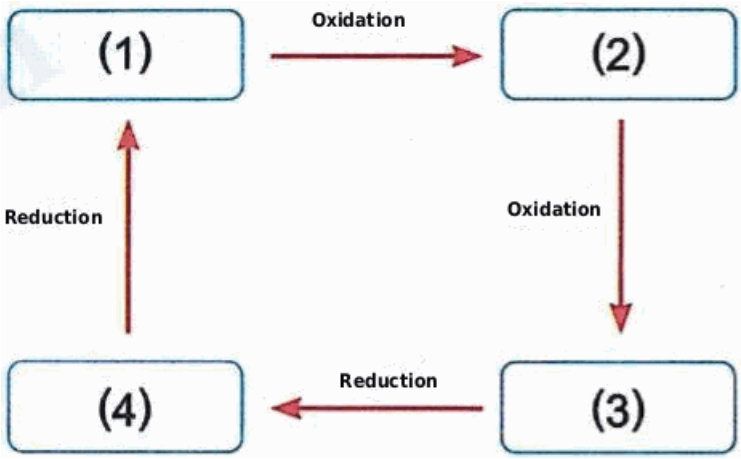
(B) (1): Fe_3O_4 , (2): FeO , (3): Fe , (4): Fe_2O_3

(C) (1): Fe_3O_4 , (2): Fe , (3): FeO , (4): Fe_2O_3

(D) (1): Fe_2O_3 , (2): Fe , (3): Fe_3O_4 , (4): FeO

70 The opposite scheme includes oxidation and reduction reactions of iron and its oxides.

Which of the following is correct?



(A) (1): a black oxide , (2): a black oxide , (3): a red oxide , (4): iron

(B) (1): a black oxide , (2): a red oxide , (3): a black oxide , (4): iron

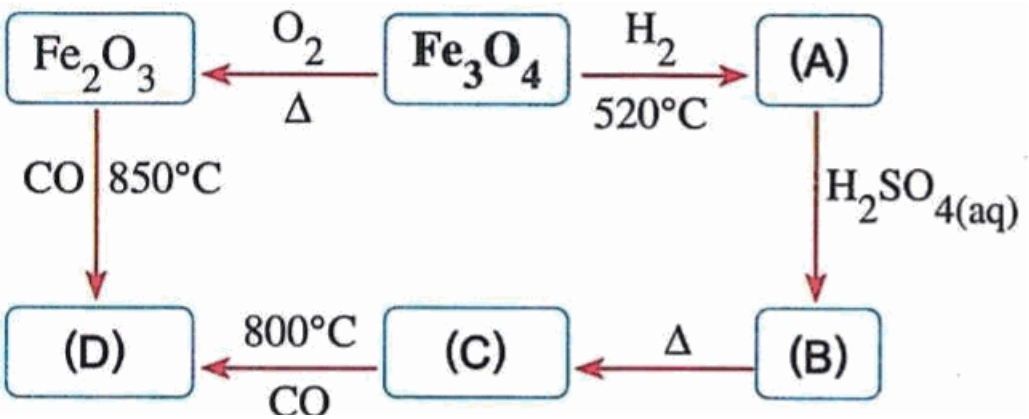
(C) (1): iron , (2): a black oxide , (3): a red oxide , (4): a black oxide

(D) (1): iron , (2): a red oxide , (3): a black oxide , (4): a black oxide

---

71 From the opposite chart:

Which of the following is correct?



(A) (A): Fe_2O_3 , (B): $FeSO_4$, (C): FeO

(B) (A): FeO , (B): $FeSO_4$, (D): Fe

(C) (B): Fe_2O_3 , (C): Fe , (D): $FeSO_4$

(D) (B): Fe , (C): Fe_2O_3 , (D): FeO

Essay questions — 12 questions

1 Iron oxide (X) can be obtained by reducing the other two iron oxides.
Show with symbolic equations how oxide (X) is obtained from:
(1) one of the other two oxides.
(2) a thermal decomposition reaction.

2 Iron oxide (X) can be obtained by oxidizing the other two iron oxides.
Show with symbolic equations how oxide (X) is obtained from two thermal decomposition reactions.

3 The following table shows the results of the reactions of three metals of the first transition series with dilute sulphuric acid and with air:
• Metal (M): reaction with dilute sulphuric acid: dissolves slowly forming a solution, with gas bubbles , reaction with air on heating: forms the black oxide (1)
• Manganese: reaction with dilute sulphuric acid: dissolves quickly in the acid forming the stable solution (2), with gas bubbles given off , reaction with air on heating: forms oxide (3), which is a mixture of the (II) and (III) oxides
• Chromium: reaction with dilute sulphuric acid: dissolves quickly in the acid forming a solution , reaction with air on heating: forms oxide (4), which is used in making dyes
Deduce the chemical formula of each of:
(1) oxide (1).
(2) solution (2).
(3) oxide (3).
(4) oxide (4).

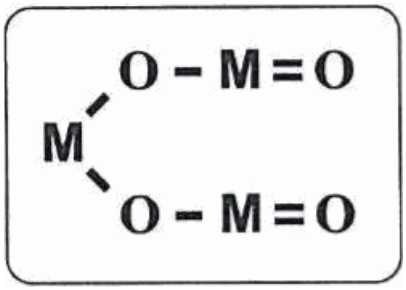
4 Metal (M) is used in making surgical instruments, and the opposite structural formula represents one of its oxides:

(1) Explain why this oxide is described as mixed, using the two oxidation numbers of metal (M) in it.

(2) Show with a symbolic equation the product of:

(a) reducing this oxide.

(b) oxidizing this oxide.



5 The number of moles of the substance produced from combining 4 mol of iron with excess sulphur equals that produced with excess chlorine.

Express the previous statement with two symbolic equations that show it.

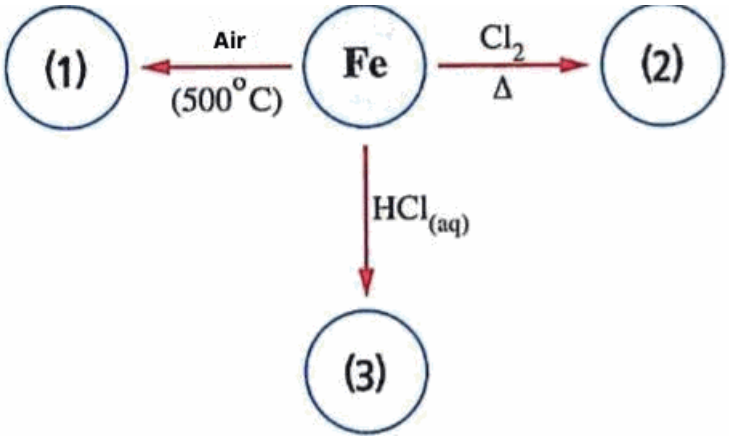
6 From the opposite chart:

(1) Give two properties of compound (1).

(2) Write the electron configuration of the iron ion in:

(a) compound (2).

(b) compound (3).



7 2 mol of iron oxide (X) are oxidized forming 1 mol of oxide (Y), while 3 mol of oxide (Y) are reduced forming 2 mol of oxide (Z):

(1) Give the chemical formula of:

(a) oxide (X).

(b) oxide (Z).

(2) Can oxide (Y) be oxidized? Explain.

---

8 Metal (X) is soft in the pure state, so carbon is added to it in definite ratios to increase its hardness. One of its oxides is XO.

Write the balanced symbolic equation for the reaction of:

(1) metal (X) with air (at 500°C).

(2) oxide XO with dilute hydrochloric acid.

---

9 From the following two statements:

• Statement (1): when a sample of the black iron ore (X) is heated in air, it changes into the red compound (Y).

• Statement (2): the product of reducing compound (Y) differs with the reaction temperature.

(1) What is the ratio between the number of moles of compound (Y) and the number of moles of the ore compound (X) in the balanced equation?

(2) What oxide is produced by reducing compound (Y) at:

(a) the lowest possible temperature?

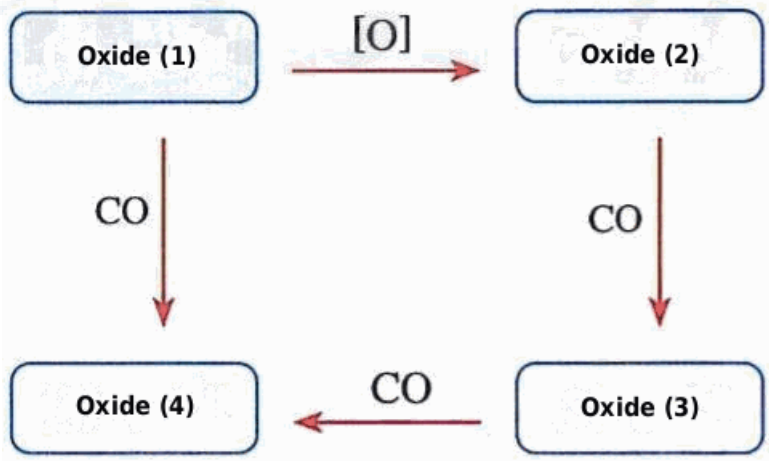
(b) the highest possible temperature?

---

10 The opposite chart includes the three iron oxides:

(1) Give the numbers of the two oxides that have the same chemical formula.

(2) What is the number of the oxide that reacts with hot concentrated sulphuric acid, forming only iron(III) sulphate solution and steam?

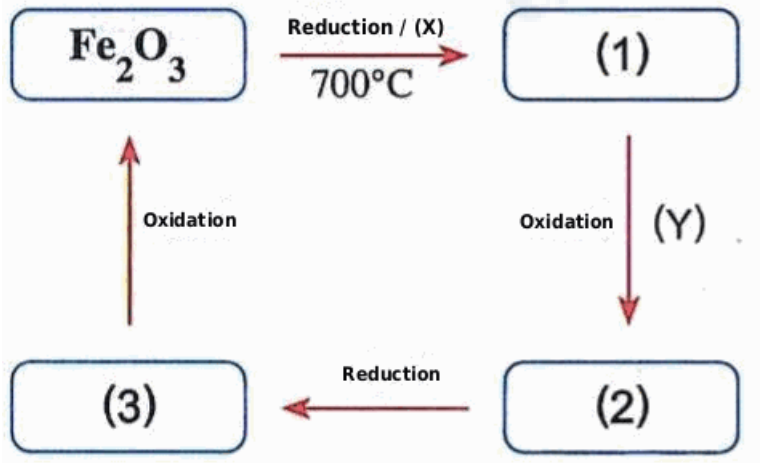


11 The opposite chart shows oxidation and reduction processes of the three iron oxides.

Write the symbolic equation for:

(1) the reduction reaction (X).

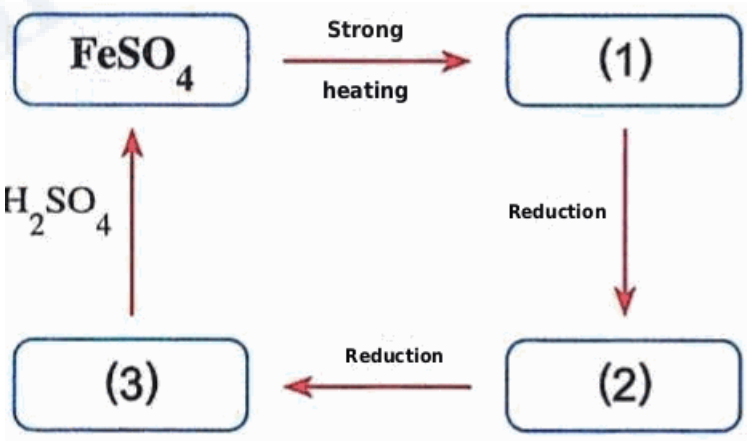
(2) the oxidation reaction (Y).



12 From the opposite chart, write the two symbolic equations that show changing:

(1) the compound $FeSO_4$ into compound (2).

(2) compound (2) into $FeSO_4$



Past exam questions — 28 questions

1 Which of the following processes increases the oxidation state of the iron ion in its compounds?
(Sample exam 2026)

(A) Heating the compound produced by adding ammonium hydroxide to iron(III) chloride to above 200°C

(B) Heating the compound produced by adding iron to dilute sulphuric acid.

(C) Strongly heating limonite ore in air.

(D) Heating siderite ore away from air.

---

2 Which of the following is needed to prepare iron(III) sulphate from iron(II) sulphate?
(Sample exam 2026)

(A) Thermal decomposition, then adding dilute sulphuric acid.

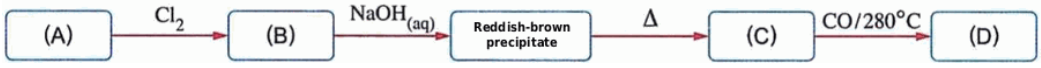
(B) Thermal decomposition, then adding concentrated sulphuric acid.

(C) Adding sodium hydroxide, then adding dilute sulphuric acid.

(D) Oxidation, then adding sodium hydroxide.

---

3 The following chart shows some reactions of iron and its compounds:
From the previous chart, which of the following is correct?
(Sample exam 2026)



(A) Replacing chlorine with dilute hydrochloric acid gives the same product (B).

(B) Both (A) and (D) react with concentrated sulphuric acid giving a mixture of iron(II) and iron(III) sulphates.

(C) Compounds (B) and (C) have the same magnetic moment, and (C) can be reduced to (A) with hydrogen at 500°C

(D) Compound (C) reacts with dilute hydrochloric acid to give compound (B).

---

4 Fe_2O_3 can be obtained by all the following methods, except .....

(Sample exam 2026)

(A) Adding H_2SO_4(dil) to the product of reducing Fe_3O_4 / adding an alkali / heating above 200°C

(B) Passing hot air over iron heated to redness / oxidation.

(C) Leaving iron(II) sulphate in air for some time / adding an alkali / heating above 200°C

(D) Adding iron to dilute oxalic acid / heating in air.

---

5 Which of the following gives the correct order of the processes needed to obtain a black iron oxide from $FeCl_3$?

(Sample exam 2026)

(A) Adding an alkaline solution – thermal decomposition – reduction.

(B) Thermal decomposition – oxidation – adding an alkaline solution.

(C) Adding an alkaline solution – reduction – thermal decomposition.

(D) Thermal decomposition – reduction – adding an alkaline solution.

---

6 Which of the following gives the order of the processes carried out on magnetic iron oxide to obtain a reddish-brown precipitate?

(Sample exam 2026)

(A) Reacting with concentrated sulphuric acid, then adding ammonia solution after some time.

(B) Oxidation, then reacting with dilute sulphuric acid, then adding ammonia solution.

(C) Reduction at 430°C, then reacting with dilute hydrochloric acid, then adding ammonia solution.

(D) Reacting with dilute hydrochloric acid, then adding ammonia solution.

---

7 (A) and (B) are iron(II) salts; the thermal decomposition of each of them in the absence of air gives one of the iron oxides, as shown by the following equations:

$A(s) \xrightarrow{(\Delta)} C(s) + D(g) + E(g)$

$B(s) \xrightarrow{(\Delta)} G(s) + L(g) + M(g)$

Gas (D) is a reducing agent in the extraction of iron.

Which of the following gives (A), (B), (C) and (G)?

(Sample exam 2026)

(A) (A): $(COO)_2Fe$, (B): $FeSO_4$, (C): FeO , (G): Fe_2O_3

(B) (A): $Fe(OH)_3$, (B): $FeCO_3$, (C): Fe_2O_3 , (G): FeO

(C) (A): $(COO)_2Fe$, (B): $FeSO_4$, (C): Fe_2O_3 , (G): FeO

(D) (A): $FeCO_3$, (B): $Fe(OH)_3$, (C): FeO , (G): Fe_2O_3

---

8 The following chart shows reactions of iron compounds:

Which of the following gives the chemical formulas of (X), (Y) and (Z)?

(Sample exam 2026)



(A) (X): Fe_2O_3 , (Y): Fe , (Z): Fe_3O_4

(B) (X): Fe_3O_4 , (Y): FeO , (Z): Fe_2O_3

(C) (X): Fe_2O_3 , (Y): FeO , (Z): Fe_3O_4

(D) (X): FeO , (Y): Fe , (Z): Fe_2O_3

---

9 Which of the following steps are correct for obtaining iron(III) hydroxide from iron(II) oxalate?

(2nd session 2024)

(A) Heating away from air – adding HCl – adding NH_4OH

(B) Heating in air – reduction at 500°C – adding dilute sulphuric acid – adding NH_4OH

(C) Heating in air – reduction at 800°C – adding chlorine – adding NH_4OH

(D) Adding HCl – adding NH_4OH – heating to redness

---

10 Iron filings can be used to distinguish between .....

(Trial exam / June 2021)

(A) concentrated sulphuric acid and concentrated nitric acid.

(B) dilute hydrochloric acid and dilute sulphuric acid.

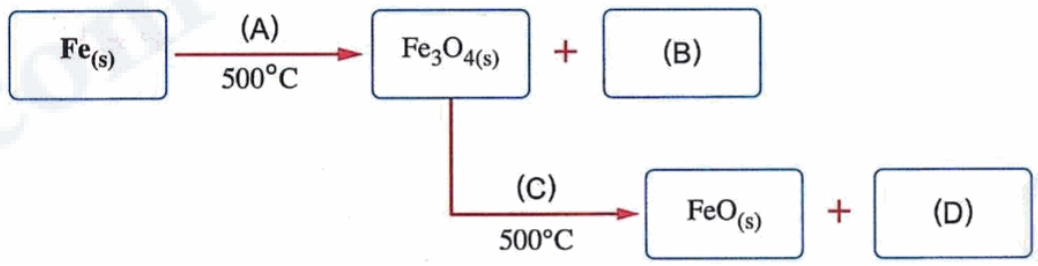
(C) iron(II) sulphate and iron(III) sulphate.

(D) iron(III) oxide and iron(III) sulphate.

11 From the opposite chart:

The substances (A), (B), (C) and (D), respectively, are .....

(2nd session 2022)



(A) (A): $H_2O(v)$, (B): $CO_2(g)$, (C): $H_2(g)$, (D): $CO_2(g)$

(B) (A): $O_2(g)$, (B): $CO(g)$, (C): $H_2(g)$, (D): $H_2O(v)$

(C) (A): $H_2O(v)$, (B): $H_2(g)$, (C): $CO(g)$, (D): $CO_2(g)$

(D) (A): $O_2(g)$, (B): $H_2O(v)$, (C): $CO(g)$, (D): $CO_2(g)$

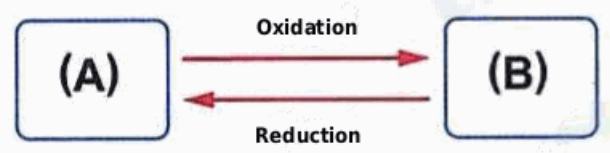
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12 From the opposite chart:

Given that (A) and (B) are both iron compounds,

the choice that gives (A) and (B) is .....

(2nd session 2022)



(A) (A): Fe_2O_3 , (B): FeO

(B) (A): $FeSO_4$, (B): $Fe_2(SO_4)_3$

(C) (A): Fe_3O_4 , (B): FeO

(D) (A): $(COO)_2Fe$, (B): $FeSO_4$

---

13 When iron(II) oxalate is strongly heated in atmospheric air, a solid compound (X) is formed, and when hot concentrated sulphuric acid is added to compound (X), another compound (Y) is formed. Comparing the properties of compounds (X) and (Y), we find that .....
(Trial exam / May 2021)

(A) compound (X) is greater than compound (Y) in magnetic moment, and compound (Y) does not dissolve in water.

(B) compound (X) equals compound (Y) in magnetic moment, and compound (X) dissolves in water.

(C) compound (X) equals compound (Y) in magnetic moment, and compound (Y) dissolves in water.

(D) compound (Y) is greater than compound (X) in magnetic moment, and compound (X) does not dissolve in water.

---

14 Which of the following processes happen to iron(II) oxalate, in order, to produce iron?
(1st session 2023)

(A) Oxidation – reduction – thermal decomposition.

(B) Thermal decomposition – oxidation – reduction.

(C) Reduction – oxidation – thermal decomposition.

(D) Thermal decomposition – reduction – oxidation.

---

15 When dilute sulphuric acid was added to substance (X), a salt solution was formed; after some time, ammonia solution was added to the product and a precipitate was formed.
Which of the following choices is correct «for substance (X) – the salt – the precipitate, respectively»?
(Trial exam / March 2023)

(A) Substance (X): FeO , salt: $FeSO_4$, precipitate: $Fe(OH)_2$

(B) Substance (X): Fe_2O_3 , salt: $Fe_2(SO_4)_3$, precipitate: $Fe(OH)_3$

(C) Substance (X): Fe_3O_4 , salt: $Fe_2(SO_4)_3$, precipitate: $Fe(OH)_2$

(D) Substance (X): FeO , salt: $FeSO_4$, precipitate: $Fe(OH)_3$

---

16 Which of the following processes is correct for obtaining red iron oxide?
(Trial exam / March 2023)

(A) Heating iron in air to redness for a short time.

(B) Adding dilute sulphuric acid to iron(II) oxide, then heating the product.

(C) Heating iron(II) carbonate away from atmospheric air.

(D) Passing hot steam over iron heated at 500°C

---

17 When the compounds FeO, Fe_3O_4 and $FeCO_3$ are heated strongly in atmospheric air, each one separately, and the mass of the solid product after heating is compared, ...
[Fe = 56 , C = 12 , O = 16]
(Trial exam / May 2021)

(A) the mass of Fe_3O_4 is not affected and the mass of FeO increases

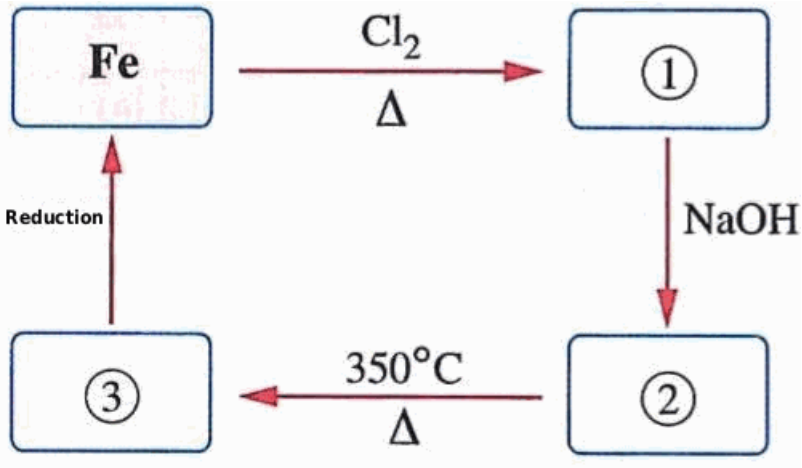
(B) the mass of $FeCO_3$ increases and the mass of Fe_3O_4 is not affected

(C) the mass of $FeCO_3$ increases and the mass of FeO decreases

(D) the mass of $FeCO_3$ decreases and the mass of Fe_3O_4 increases

---

18 Study the opposite chart. Which of the following gives compounds (1), (2) and (3), respectively?
(Trial exam / May 2021)



(A) (1): $FeCl_2$, (2): Fe_2O_3 , (3): $Fe(OH)_3$

(B) (1): $FeCl_3$, (2): $Fe(OH)_3$, (3): Fe_2O_3

(C) (1): $FeCl_3$, (2): Fe_2O_3 , (3): $Fe(OH)_3$

(D) (1): $FeCl_2$, (2): FeO , (3): $Fe(OH)_2$

---

19 Which of the following steps are correct for obtaining iron(III) hydroxide from iron(II) oxide?
(1st session 2024)

(A) Heating in air – reduction at a temperature above 700°C – adding hot concentrated sulphuric acid – adding ammonium hydroxide solution.

(B) Adding hydrochloric acid – adding ammonium hydroxide solution – heating away from air.

(C) Heating in air – reduction at 400°C – adding dilute sulphuric acid – adding ammonium hydroxide solution.

(D) Strong heating in air – adding hot concentrated sulphuric acid – adding ammonium hydroxide solution.

---

20 To obtain magnetic iron oxide from iron(III) chloride, the processes that must be carried out, in order, are .....
(1st session 2021)

(A) reacting with hydrochloric acid – oxidation – reduction.

(B) reacting with an alkaline solution – thermal decomposition – reduction.

(C) oxidation – reduction – thermal decomposition.

(D) thermal decomposition – oxidation – reacting with an alkaline solution.

---

21 When dilute sulphuric acid is added to a test tube containing a mixture of iron(II) oxide and iron(III) oxide, after the reaction is complete the tube will contain .....
(2nd session 2021)

(A) iron(III) sulphate, iron(III) oxide and hydrogen.

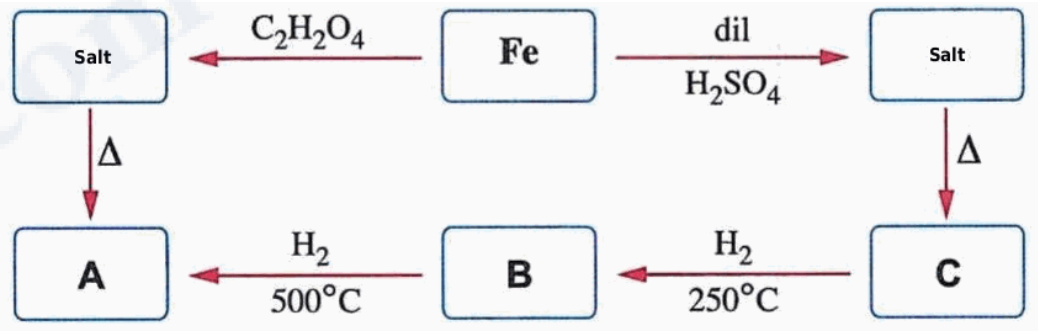
(B) iron(II) oxide, iron(III) oxide and sulphur dioxide.

(C) iron(II) sulphate, iron(III) oxide and water.

(D) iron(III) sulphate, hydrogen and sulphur dioxide.

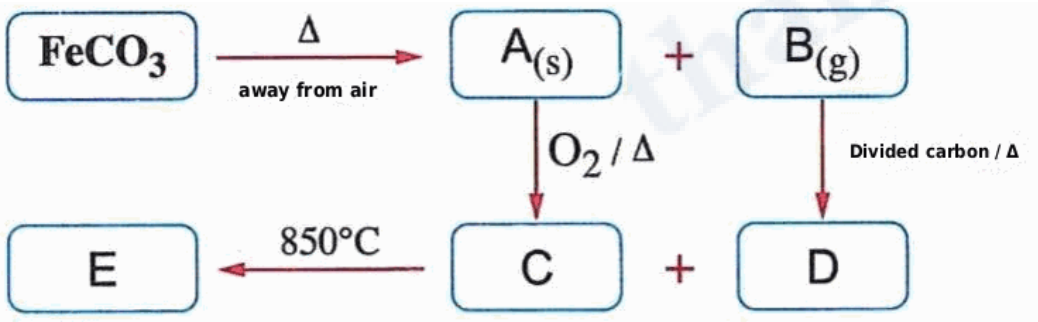
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22 The following chart shows reactions of iron and its oxides under their suitable conditions:
Which of the following choices gives (A), (B) and (C)?
(1st session 2023)



(A) (A): Fe_3O_4 , (B): FeO , (C): Fe_2O_3
(B) (A): FeO , (B): Fe_3O_4 , (C): Fe_2O_3
(C) (A): FeO , (B): Fe_2O_3 , (C): Fe_3O_4
(D) (A): Fe_2O_3 , (B): Fe_3O_4 , (C): FeO

23 The following chart shows some reactions under their suitable conditions:
Which of the following choices is correct for compounds (A), (C) and (E)?
(2nd session 2023)



(A) (A): Fe_2O_3 , (C): Fe , (E): FeO
(B) (A): FeO , (C): Fe_2O_3 , (E): Fe
(C) (A): Fe_3O_4 , (C): FeO , (E): Fe
(D) (A): FeO , (C): Fe_3O_4 , (E): Fe_2O_3

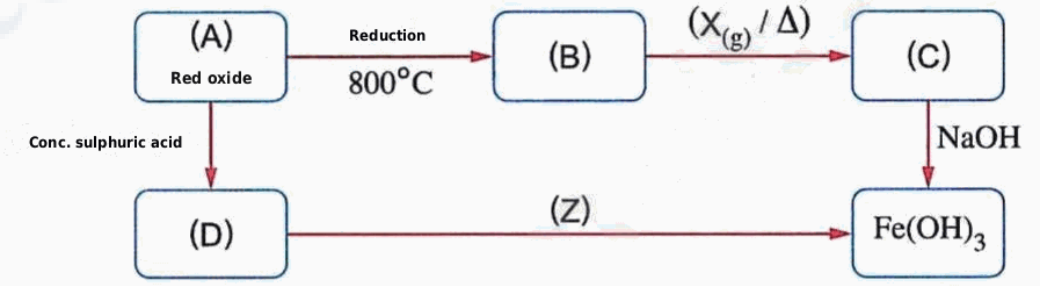
24 The following chart shows iron and its compounds:

(1) Write the chemical formulas of (C) and (D).

(2) Name an intermetallic alloy of substance (B).

(3) Name compound (C) when (X) is replaced with dilute HCl.

(Sample exam 2026)



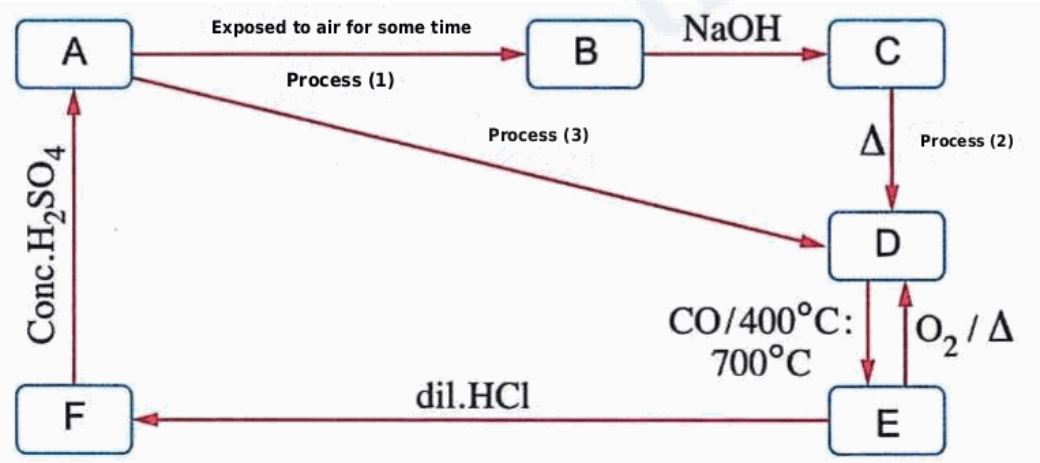
25 The following chart shows some processes carried out on some iron compounds:

(1) Write the chemical formulas of (F) and (B).

(2) Give the number of the process that is a thermal decomposition with no change in the magnetic moment of the iron ion.

(3) Name process number (3).

(Sample exam 2026)

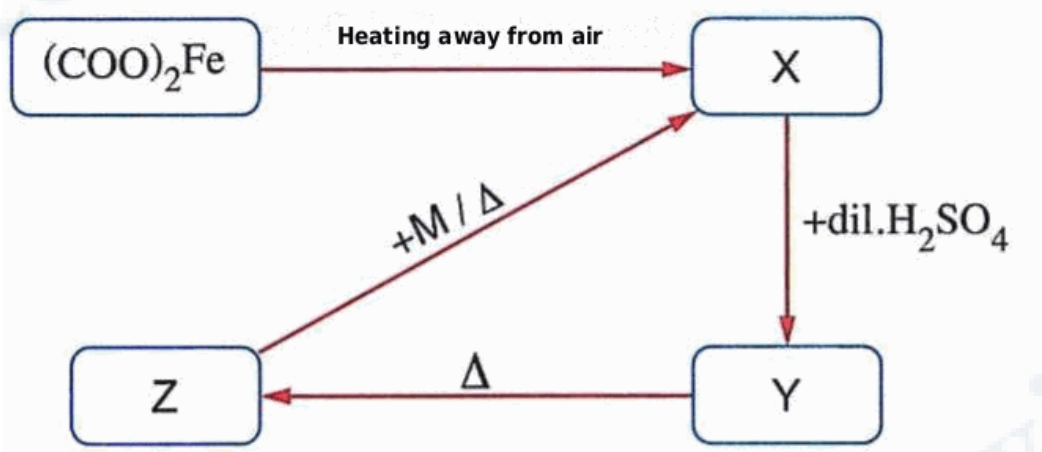


26 Study the following chart, then answer:

(1) Write the chemical formulas of the compounds (X), (Y) and (M).

(2) Write the chemical formula of the compound with the highest magnetic moment in the previous chart.

(Sample exam 2026)

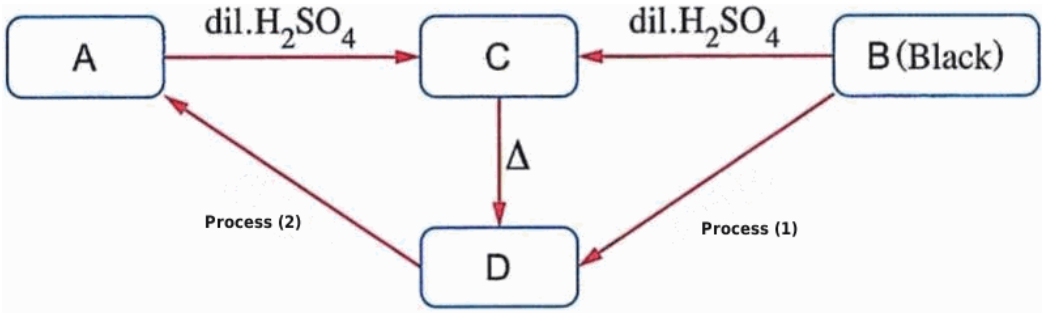


27 The following chart shows some reactions of iron and its compounds:

(1) Name process number (1) and process number (2).

(2) Write the chemical formula of each of (C) and (D).

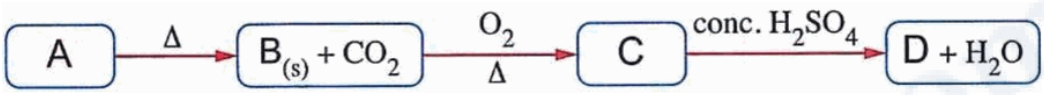
(Sample exam 2026)



28 Study the following chart of iron compounds, then answer:

What are the chemical formulas of the compounds (A), (B), (C) and (D)?

(1st session 2025)



Answer key and solutions

Multiple choice questions

1 D	2 A	3 B	4 A	5 C	6 B	7 C	8 C	9 A	10 B
11 D	12 B	13 D	14 C	15 D	16 D	17 C	18 A	19 B	20 C
21 B	22 B	23 C	24 C	25 B	26 D	27 C	28 B	29 C	30 B
31 B	32 D	33 A	34 D	35 C	36 C	37 B	38 C	39 B	40 B
41 D	42 B	43 C	44 C	45 A	46 B	47 B	48 D	49 B	50 D
51 D	52 C	53 D	54 B	55 B	56 B	57 C	58 C	59 D	60 B
61 D	62 C	63 D	64 C	65 D	66 C	67 C	68 D	69 D	70 C
71 B									

1 **Answer (D)**

Iron is magnetic (strongly paramagnetic), while zinc Zn is diamagnetic

So statement (D) is not correct

2 **Answer (A)**

(1) Changing Fe_2O_3 into Fe is reduction

(2) Changing Fe into (A) with chlorine is oxidation, and the product is $FeCl_3$

3 **Answer (B)**

Roasting siderite gives A, which is Fe_2O_3 (red)

Water gas reduces Fe_2O_3 to B, which is Fe

Heating Fe in air gives C, which is Fe_3O_4

4 **Answer (A)**

$3Fe + 4H_2O(v) \longrightarrow (500°C)\ Fe_3O_4 + 4H_2$

The concentrated acid does not give H_2, and water at 100°C does not react with iron

5 **Answer (C)**

The catalyst in preparing ammonia is iron

Its reaction with hot air gives Fe_3O_4

6 **Answer (B)**

$Fe + S \longrightarrow FeS$ in the ratio 1 : 1

So 4 mol of sulphur are needed to react with 4 mol of iron

7 **Answer (C)**

FeS and $FeCl_3$ can each be prepared directly from iron (with sulphur and chlorine)

FeS is paramagnetic and Cu_2Cl_2 is diamagnetic, and FeS can be oxidized unlike ZnO

8 **Answer (C)**

$FeCl_2$ and $FeSO_4$ are paramagnetic iron(II) salts that dissolve in water

But $FeCl_2$ contains two Cl^- ions, while $FeSO_4$ contains one SO_4^{2-} ion

9 **Answer (A)**

Iron with air or steam at 500°C gives Fe_3O_4 (the magnetic oxide)

10 **Answer (B)**

Iron reacts with hot concentrated sulphuric acid, so statement (B) is not correct

$FeCl_3$ is not oxidized because Fe^{3+} is the highest state

11 **Answer (D)**

(1) $FeCl_3$ (+3) and (3) $FeCl_2$ (+2), which is easily oxidized

(2) is a dilute acid such as HCl because it gives H_2, while concentrated nitric acid does not give H_2

12 **Answer (B)**

Sulphuric acid gives different products with iron when dilute ($FeSO_4$ and H_2) and when hot concentrated (iron(II) and iron(III) sulphates with SO_2)

The common product is Fe^{2+} ions

13 **Answer (D)**

(1) O_2 oxidizes carbon

(2) Fe^{3+} in Fe_2O_3 oxidizes the water gas

(3) H^+ oxidizes iron in HCl

14 **Answer (C)**

Iron with steam or oxygen at 500°C gives Fe_3O_4 (the strong magnet)

15 **Answer (D)**

Concentrated nitric acid makes iron passive by forming an oxide layer on its surface

16 **Answer (D)**

Iron in concentrated nitric acid is covered with an oxide layer that protects it

When it is moved to dilute HCl, the H_2 bubbles are delayed until the layer dissolves

17 **Answer (C)**

(1) Fe_3O_4, from heating iron in air

(2) $FeCl_3$, from chlorine

(3) $FeCl_2$, from dilute HCl

18 **Answer (A)**

Siderite: roasting to Fe_2O_3, then reduction to Fe at 800°C, then oxidation with chlorine to $FeCl_3$

19 **Answer (B)**

Iron reacts with hot concentrated H_2SO_4 and forms iron(II) and iron(III) salts

So its path reaches (2)

20 **Answer (C)**

The density of iron (7.87) is greater than that of manganese (7.43), so yes

It reacts with sulphur, so yes

And the oxidation number of iron in FeS is +2

21 **Answer (B)**

Heating FeC_2O_4 in air oxidizes Fe^{2+}, giving Fe_2O_3 and CO_2

22 **Answer (B)**

Limonite is roasted to Fe_2O_3, then reduced at about 600°C to FeO

23 **Answer (C)**

The mass decreases when the oxalate and the carbonate decompose and when the oxide is reduced

But it increases when iron is heated in air because it gains oxygen

24 **Answer (C)**

MnO_4^- oxidizes Fe^{2+} to Fe^{3+} and is reduced to Mn^{2+}

25 **Answer (B)**

This oxide is FeO

It is formed from the decomposition of siderite (away from air) and from the reduction of Fe_2O_3 with hydrogen at 650°C

But roasting FeC_2O_4 in air gives Fe_2O_3, not FeO

26 **Answer (D)**

FeO is a basic oxide that is oxidized in hot air and dissolves in acids

Its reduction needs heating and a reducing agent, so it is not easy at room temperature

27 **Answer (C)**

Reducing Fe_2O_3 with hydrogen at 500°C gives FeO

FeO is a basic oxide that dissolves in H_2SO_4, forming $FeSO_4$

28 **Answer (B)**

FeO is completely oxidized to Fe_2O_3

$4FeO + O_2 \longrightarrow 2Fe_2O_3$, so 2 mol of FeO give 1 mol of Fe_2O_3

29 **Answer (C)**

R_3O_4, RCl_2 and RO fit iron (Fe_3O_4, $FeCl_2$ and FeO)

Copper does not react with HCl

30 **Answer (B)**

Strongly heating $FeSO_4$ away from air: $2FeSO_4 \longrightarrow Fe_2O_3 + SO_2 + SO_3$

So Fe^{2+} is oxidized to Fe^{3+}

The oxalate and the carbonate give FeO

31 **Answer (B)**

Red Fe_2O_3 is formed by oxidizing Fe_3O_4, by roasting the oxalate and by decomposing $Fe(OH)_3$

Heating iron in air gives black Fe_3O_4

32 **Answer (D)**

FeO is produced by reducing Fe_2O_3 with hydrogen (2) and reacts with dilute acids (4)

Roasting FeC_2O_4 in air gives Fe_2O_3, not FeO

33 **Answer (A)**

34 **Answer (D)**

Heating iron in air gives Fe_3O_4 (black)

Heating siderite away from air produces FeO (black)

H_2 over haematite at 550°C produces FeO (black)

But strongly heating $FeSO_4$ gives red Fe_2O_3

35 **Answer (C)**

Heating $FeSO_4$: thermal decomposition, in which Fe^{2+} is oxidized to Fe^{3+} and sulphur is reduced from +6 to +4

So it is decomposition and oxidation-reduction

36 **Answer (C)**

Hydrated $FeSO_4$ gives steam on heating, then SO_2 and SO_3

Then the oxide formed is reduced to iron with carbon, so CO_2 is formed

37 **Answer (B)**

$Fe(OH)_3 \longrightarrow$(thermal decomposition) $Fe_2O_3 \longrightarrow$(reduction) FeO

38 **Answer (C)**

The yellow hydrated ore is limonite (hydrated iron(III) oxide) and metal M is iron

The one that decomposes into FeO, SO_2 and SO_3 is $FeSO_4$, not limonite

39 **Answer (B)**

FeO + dilute $H_2SO_4 \longrightarrow FeSO_4 + H_2O$

The colour changes from black to a green solution, no gas is given off and no precipitate is formed

40 **Answer (B)**

(1) $FeCO_3$ decomposes by heat to FeO (W) (2) oxidation of FeO to Fe_2O_3 (X)

(3) Fe_2O_3 with hot concentrated HCl gives $FeCl_3$ (Y) , (4) NaOH precipitates $Fe(OH)_3$

Fe_2O_3 does not dissolve in dilute HCl

41 **Answer (D)**

(1) Reduction of Fe_2O_3 (A) to Fe

(2) Oxidation of Fe with chlorine to $FeCl_3$ (B)

(X) is NaOH(aq), which gives a reddish-brown precipitate of $Fe(OH)_3$

(3) Thermal decomposition of $Fe(OH)_3$ to Fe_2O_3

42 **Answer (B)**

The red colour in paints is Fe_2O_3 (iron +3)

It is reduced by CO above 700°C to iron

43 **Answer (C)**

Fe_2O_3 does not dissolve in dilute HCl (it needs a hot concentrated acid)

44 **Answer (C)**

The red rock is haematite Fe_2O_3

It reacts with hot concentrated H_2SO_4: $Fe_2O_3 + 3H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 3H_2O$

45 **Answer (A)**

Reduce Fe_3O_4 with hydrogen to FeO, then oxidize it to Fe_2O_3

Then neutralize Fe_2O_3 with hot concentrated HCl, which gives $FeCl_3$

46 **Answer (B)**

$FeO + SO_3 \longrightarrow FeSO_4$ in the ratio 1 : 1

$FeSO_4$ decomposes by heat to Fe_2O_3

47 **Answer (B)**

Strongly heating $FeSO_4$ gives Fe_2O_3 (1)

Its partial reduction gives Fe_3O_4 (2), then FeO (3)

FeO with H_2SO_4 gives back $FeSO_4$

48 **Answer (D)**

Reducing Fe_2O_3 gives products that differ with temperature (Fe_3O_4, then FeO, then Fe)

So statement (D) is not correct

49 **Answer (B)**

$FeSO_4 \longrightarrow Fe_2O_3$ by strong heating

$Fe_2O_3 + 6HCl \longrightarrow 2FeCl_3 + 3H_2O$

So to produce 4 mol of $FeCl_3$, 2 mol of Fe_2O_3 and 12 mol of HCl are needed

50 **Answer (D)**

(1) $Fe(OH)_3 \longrightarrow$ (above 200°C) (2) Fe_2O_3

Fe_2O_3 with concentrated H_2SO_4 gives (3) $Fe_2(SO_4)_3$

And ammonia solution changes $Fe_2(SO_4)_3$ back into $Fe(OH)_3$

51 **Answer (D)**

$FeSO_4$ + NH_4OH gives $Fe(OH)_2$ and $(NH_4)_2SO_4$

$FeCl_3$ + NH_4OH gives (3) $Fe(OH)_3$ and NH_4Cl

$Fe(OH)_3$ decomposes on strong heating to Fe_2O_3, a red powder

52 **Answer (C)**

(X) $FeSO_4$ gives Fe_2O_3 on strong heating

(Y) FeC_2O_4 gives FeO away from air

(Z) Iron at 500°C in air gives Fe_3O_4

53 **Answer (D)**

(X) is a salt ($FeCl_3$), which gives with NH_4OH (Y), the hydroxide $Fe(OH)_3$

(Y) on heating gives (Z), the oxide Fe_2O_3, which with hot concentrated HCl gives back the salt

54 **Answer (B)**

Fe with Cl_2 on heating gives $FeCl_3$ (2)

$FeCl_3$ + NH_4OH ⟶ $Fe(OH)_3$ (4) + NH_4Cl (3)

55 **Answer (B)**

(X) is Fe_2O_3 and (Y) is Fe_3O_4 (reduction at 270°C)

Both react only with hot concentrated acids

56 **Answer (B)**

The formula M_3O_4 is Fe_3O_4 and element (M) is iron

It can be obtained by reducing the iron oxide Fe_2O_3

57 **Answer (C)**

The coloured ones: $Fe(OH)_3$ (reddish brown), Fe_2O_3 (red) and Fe_3O_4 (black)

Water is colourless

58 **Answer (C)**

Heating iron in air gives Fe_3O_4

Fe_3O_4 + H_2 ⟶(600°C) 3FeO + H_2O in the ratio 1 : 1

59 **Answer (D)**

Fe_2O_3 is prepared by oxidizing Fe_3O_4 and by roasting the oxalate

It reacts with hot concentrated acids forming Fe^{3+} salts

But reduction gives oxides lower in oxidation, not Fe_2O_3

60 **Answer (B)**

Red iron oxide Fe_2O_3 does not react with dilute acids (only hot concentrated ones)

61 **Answer (D)**

This oxide is $Fe_3O_4 = FeO \cdot Fe_2O_3$

With hot concentrated acids it gives Fe^{2+} and Fe^{3+} salts

62 **Answer (C)**

$Fe_3O_4 + 8HCl \longrightarrow FeCl_2 + 2FeCl_3 + 4H_2O$

So 2 mol of $FeCl_3$ are produced (the products are 7 mol, and the Cl^- ions 8 mol)

63 **Answer (D)**

The reddish-brown precipitate is $Fe(OH)_3$, so we need an Fe^{3+} salt

We oxidize Fe_3O_4 to Fe_2O_3, then dissolve it in hot concentrated HCl, which gives $FeCl_3$

64 **Answer (C)**

Fe heated in air gives Fe_3O_4

With hot concentrated HCl it gives $FeCl_2$, $FeCl_3$ and water

65 **Answer (D)**

The two black oxides are FeO and Fe_3O_4

$4FeO + O_2 \longrightarrow 2Fe_2O_3$, so 1 mol of FeO gives 0.5 mol of Fe_2O_3

66 **Answer (C)**

$4Fe_3O_4 + O_2 \longrightarrow 6Fe_2O_3$

So the ratio is 4 : 6 = 2 : 3

67 **Answer (C)**

(1) $4Ca + Fe_3O_4 \longrightarrow 4CaO + 3Fe$, so (W) is a magnetic compound

(2) $3C + 2Fe_2O_3 \longrightarrow 3CO_2 + 4Fe$, so (X) is iron, the backbone of heavy industries

(3) $4FeS + 7O_2 \longrightarrow 4SO_2 + 2Fe_2O_3$, so (Y) is red

(4) $CO + FeO \longrightarrow CO_2 + Fe$, so (Z) is black

68 **Answer (D)**

$FeO + H_2SO_4 \longrightarrow FeSO_4$, then strong heating $\longrightarrow Fe_2O_3$, then reduction $\longrightarrow Fe_3O_4$

This is what Figure (D) shows

69 **Answer (D)**

(1) Fe_2O_3 ⟶ reduction Fe (2) ⟶ oxidation Fe_3O_4 (3) ⟶ reduction FeO (4) ⟶ oxidation Fe_2O_3

70 **Answer (C)**

(1) iron ⟶ oxidation a black oxide (2) ⟶ oxidation a red oxide (3) ⟶ reduction a black oxide (4) ⟶ reduction iron

71 **Answer (B)**

$Fe_3O_4 + H_2$ (520°C) gives (A) FeO

FeO + H_2SO_4 gives (B) $FeSO_4$, and heating it gives (C) Fe_2O_3

Reducing Fe_2O_3 with CO gives (D) iron

Essay questions

1 **Model answer**

(1) • $Fe_2O_3 + CO \longrightarrow^{(400:700°C)} 2FeO + CO_2$

• $Fe_3O_4 + CO \longrightarrow^{(400:700°C)} 3FeO + CO_2$

(2) • $FeC_2O_4 \longrightarrow^{(\Delta,\text{ away from air})} FeO + CO + CO_2$

• $FeCO_3 \longrightarrow^{(\Delta)} FeO + CO_2$

2 **Model answer**

• $2Fe(OH)_3 \longrightarrow^{(\Delta > 200°C)} Fe_2O_3 + 3H_2O$

• $2FeSO_4 \longrightarrow^{(\Delta)} Fe_2O_3 + SO_2 + SO_3$

3 **Model answer**

(1) Oxide (1): Fe_3O_4

(2) Solution (2): $MnSO_4$

(3) Oxide (3): Mn_3O_4

(4) Oxide (4): Cr_2O_3

4 **Model answer**

Iron (metal M) is used in making surgical instruments.

(1) This oxide is described as mixed because it contains iron in the two oxidation states +2 and +3

(2) (a) $Fe_3O_4 + H_2 \longrightarrow^{(400:700°C)} 3FeO + H_2O$

(b) $2Fe_3O_4 + ½O_2 \longrightarrow^{(\Delta)} 3Fe_2O_3$

5 **Model answer**

- $4Fe + 4S \xrightarrow{(\Delta)} 4FeS$
- $4Fe + 6Cl_2 \xrightarrow{(\Delta)} 4FeCl_3$

6 **Model answer**

Iron Fe heated to redness reacts with air forming Fe_3O_4 (compound 1), reacts with chlorine forming $FeCl_3$ (compound 2), and reacts with hydrochloric acid forming iron(II) chloride (compound 3).

(1) «any two points»

- It has strong magnetic properties.
- It reacts with hot concentrated acids forming salts of both iron(II) and iron(III), and steam.
- It is oxidized when heated in air, forming iron(III) oxide.

(2) (a) Fe^{3+} : [Ar], $3d^5$

(b) Fe^{2+} : [Ar], $3d^6$

7 **Model answer**

$2FeO + ½O_2 \xrightarrow{(\Delta)} Fe_2O_3$

$3Fe_2O_3 + CO \xrightarrow{(230 : 300°C)} 2Fe_3O_4 + CO_2$

(1) (a) Oxide (X): FeO

(b) Oxide (Z): Fe_3O_4

(2) Oxide (Y) cannot be oxidized, because the oxidation state of iron in it is +3, which is the stable oxidation state of iron in its compounds.

8 **Model answer**

Metal (X) is iron, and its oxide XO is FeO

(1) $3Fe + 2O_2 \xrightarrow{(500°C)} Fe_3O_4$

(2) $FeO + 2HCl \xrightarrow{(dil)} FeCl_2 + H_2O$

9 **Model answer**

Magnetite Fe_3O_4, a black iron ore (X), changes on heating into haematite Fe_2O_3, which is red (Y)

(1) $2Fe_3O_4 + ½O_2 \xrightarrow{(\Delta)} 3Fe_2O_3$, the ratio between the moles of (Y) and (X) = 3 : 2

(2) (a) $3Fe_2O_3 + CO \xrightarrow{(230 : 300°C)} 2Fe_3O_4 + CO_2$ (magnetic iron oxide)

(b) $Fe_2O_3 + H_2 \xrightarrow{(400 : 700°C)} 2FeO + H_2O$ (iron(II) oxide)

10 **Model answer**

∵ Oxide (2) is reduced to oxide (3), which in turn is reduced to oxide (4).

∴ Oxide (2): Fe_2O_3 , oxide (3): Fe_3O_4 , oxide (4): FeO

∵ Oxide (1) is oxidized to oxide (2) and reduced to oxide (4).

∴ Oxide (1): Fe_3O_4

(1) The two oxides: (1) , (3).

(2) Oxide (2).

11 **Model answer**

∵ Oxide (3) is produced by reducing oxide (2), and it is oxidized back to oxide (2).

∴ Oxide (2): Fe_2O_3 , oxide (3): Fe_3O_4

∵ Oxide (2) is produced by oxidizing oxide (1).

∴ Oxide (1): FeO

(1) $Fe_2O_3 + H_2 \longrightarrow (400 : 700°C)\ 2FeO + H_2O$

(2) $4FeO + O_2 \longrightarrow (\Delta)\ 2Fe_2O_3$

12 **Model answer**

∵ Strongly heating $FeSO_4$ forms iron(III) oxide, and compound (2) is produced by reducing Fe_2O_3 and is in turn reduced to compound (3).

∴ Compound (1): Fe_2O_3 , compound (2): Fe_3O_4 , compound (3): FeO

(1) • $2FeSO_4 \longrightarrow (\Delta)\ Fe_2O_3 + SO_2 + SO_3$

• $3Fe_2O_3 + CO \longrightarrow (230 : 300°C)\ 2Fe_3O_4 + CO_2$

(2) • $Fe_3O_4 + H_2 \longrightarrow (400 : 700°C)\ 3FeO + H_2O$

• $FeO + H_2SO_4 \longrightarrow (dil)\ FeSO_4 + H_2O$

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	B	B	A	A	A	A	A	C	A
11	12	13	14	15	16	17	18	19	20
C	B	C	B	D	B	D	B	D	B
21	22	23	24	25	26	27	28		
C	B	B	—	—	—	—	—		

1 **Answer (B)**

Fe + dilute H_2SO_4 gives $FeSO_4$, and strongly heating it gives Fe_2O_3

So the oxidation state of iron increases from +2 to +3

$Fe(OH)_3$ and limonite already contain +3, and siderite away from air gives FeO $(+2)$

2 **Answer (B)**

$FeSO_4 \longrightarrow$(strong heating) Fe_2O_3

Fe_2O_3 does not dissolve in the dilute acid, so hot concentrated sulphuric acid is needed to give $Fe_2(SO_4)_3$

3 **Answer (B)**

(B) is $FeCl_3$ because the reddish-brown precipitate is $Fe(OH)_3$; (C) is Fe_2O_3 and (D) is Fe_3O_4

(A) is iron; it and Fe_3O_4 (D) give Fe^{2+} and Fe^{3+} salts with hot concentrated H_2SO_4

Chlorine gives $FeCl_3$, while dilute HCl gives $FeCl_2$, so statement (A) is wrong

4 **Answer (A)**

The product of reducing Fe_3O_4 is FeO, which gives $FeSO_4$ with the acid and $Fe(OH)_2$ with the alkali

Heating $Fe(OH)_2$ above 200°C away from air gives FeO, not Fe_2O_3

5 **Answer (A)**

$FeCl_3$ + alkali $\longrightarrow$ $Fe(OH)_3$, then thermal decomposition $\longrightarrow$ Fe_2O_3, then reduction $\longrightarrow$ Fe_3O_4 (black)

6 **Answer (A)**

Fe_3O_4 + hot concentrated $H_2SO_4 \longrightarrow FeSO_4$ and $Fe_2(SO_4)_3$

After some time Fe^{2+} is oxidized by air to Fe^{3+}, so ammonia gives the reddish-brown precipitate $Fe(OH)_3$

7 **Answer (A)**

(A) is $(COO)_2Fe$: it decomposes into FeO, CO and CO_2, and CO is a reducing agent

(B) is $FeSO_4$: it decomposes into Fe_2O_3, SO_2 and SO_3

8 **Answer (A)**

The yellow ore limonite gives, on heating, X, which is Fe_2O_3

Reducing it with H_2 at 800°C gives Y, which is Fe

Strongly heating Fe in air gives Z, which is Fe_3O_4

9 **Answer (C)**

$(COO)_2Fe \longrightarrow$ heating in air $Fe_2O_3 \longrightarrow$ reduction at 800°C Fe $\longrightarrow$ chlorine $FeCl_3 \longrightarrow NH_4OH$ $Fe(OH)_3$

10 **Answer (A)**

Iron dissolves in hot concentrated H_2SO_4

But concentrated HNO_3 makes it passive (an oxide layer forms)

So they can be distinguished

11 **Answer (C)**

Fe + steam (A) $\longrightarrow Fe_3O_4 + H_2$ (B)

$Fe_3O_4 + CO$ (C) $\longrightarrow FeO + CO_2$ (D)

12 **Answer (B)**

(A) $\rightleftarrows$ (B) is oxidation and reduction of iron compounds: $FeSO_4$ is oxidized to $Fe_2(SO_4)_3$

13 **Answer (C)**

(X) is Fe_2O_3 and (Y) is $Fe_2(SO_4)_3$

The ion in each of them is Fe^{3+} ($3d^5$), so their moment is the same

And $Fe_2(SO_4)_3$ dissolves in water

14 **Answer (B)**

Iron(II) oxalate: thermal decomposition $\longrightarrow$ then oxidation to $Fe_2O_3 \longrightarrow$ then reduction to Fe

15 **Answer (D)**

FeO + dilute $H_2SO_4 \longrightarrow FeSO_4$

After some time Fe^{2+} is oxidized by air to Fe^{3+}

So ammonia gives a precipitate of $Fe(OH)_3$

16 **Answer (B)**

FeO + dilute $H_2SO_4 \longrightarrow FeSO_4$

Strongly heating $FeSO_4$ gives red Fe_2O_3

17 **Answer (D)**

$FeCO_3 \longrightarrow Fe_2O_3$: the mass decreases (from 116 to 80 per Fe)

$Fe_3O_4 \longrightarrow Fe_2O_3$: the mass increases (from 232 to 240)

$FeO \longrightarrow Fe_2O_3$: the mass increases (from 72 to 80)

18 **Answer (B)**

(1) $FeCl_3$, from iron and chlorine

(2) $Fe(OH)_3$, with the alkali

(3) Fe_2O_3, by thermal decomposition, which is then reduced to Fe

19 **Answer (D)**

FeO ⟶ strong heating in air Fe_2O_3 ⟶ hot concentrated H_2SO_4 $Fe_2(SO_4)_3$ ⟶ NH_4OH $Fe(OH)_3$

20 **Answer (B)**

$FeCl_3$ + alkali ⟶ $Fe(OH)_3$, then thermal decomposition ⟶ Fe_2O_3, then reduction ⟶ Fe_3O_4

21 **Answer (C)**

FeO + dilute H_2SO_4 ⟶ $FeSO_4$ + H_2O

Fe_2O_3 does not react with the dilute acid, so it stays as it is

22 **Answer (B)**

Strongly heating $FeSO_4$ gives C, which is Fe_2O_3

Reducing Fe_2O_3 with H_2 at 250°C gives B, which is Fe_3O_4

Then reducing it at 500°C gives A, which is FeO

23 **Answer (B)**

$FeCO_3$ away from air gives A, which is FeO, and B, which is CO_2

FeO with O_2 gives C, which is Fe_2O_3

CO_2 with carbon gives D, which is CO, and CO with Fe_2O_3 at 850°C gives E, which is Fe

24 **Model answer**

(1) (C): $FeCl_3$, (D): $Fe_2(SO_4)_3$

(2) Cementite.

(3) Iron(II) chloride.

25 **Model answer**

(1) (B): $Fe_2(SO_4)_3$, (F): $FeCl_2$

(2) Process: (2).

(3) Thermal decomposition.

26 **Model answer**

(1) (X): FeO , (Y): $FeSO_4$, (M): CO

(2) Fe_2O_3

27 **Model answer**

(1) (1): oxidation , (2): reduction.

(2) (C): $FeSO_4$, (D): Fe_2O_3

28 **Model answer**

- (A): $FeCO_3$
- (B): FeO
- (C): Fe_2O_3
- (D): $Fe_2(SO_4)_3$