College Chemistry - Quiz Questions with Answers

Descriptive Chemistry

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1.

What allotropes of oxygen exist in nature?

- **Dioxygen and trioxygen**
- Dioxygen only
- Monoxide and dioxygen
- Monoxide, dioxygen, and tetraoxygen
- Dioxygen and tetraoxygen

Correct answer: Dioxygen and trioxygen

Dioxygen (O_2) is what we breathe and require to live. Trioxygen (O_3) is also known as ozone and is found in the atmosphere.

2.

In organic chemistry, what range of pKa values can you expect to work with **most** of the time?

- **4 - 50**
- -10 - 0
- -10 - 10
- 0 - 14
- 7 - 14

Correct answer: 4 - 50

Many organic molecules have very high pKa values because they contain primarily C, H, O, and N; none of which are especially good at stabilizing negative charge. Most organic molecules, therefore, do not readily lose protons.

3.

What is the defining characteristic of a peroxide?

Oxygen has an oxidation state of -1

Oxygen forms an ionic bond with itself

Oxygen is bonded only to other oxygens

Oxygen has a free radical

Oxygen is bonded to hydrogen

Correct answer: Oxygen has an oxidation state of -1

Though oxygen almost always has a -2 oxidation state, this trend is disrupted in peroxides such as H_2O_2 and Na_2O_2. Peroxides do not contain free radicals themselves, but they are involved in various free radical pathways.

4.

What is the difference between an aldehyde and a ketone?

An aldehyde has at least one H attached to the C=O double bond, while a ketone has only C attached to the C=O double bond

An aldehyde has a C-O single bond, while a ketone a C=O double bond

An aldehyde has two H attached to the C=O double bond, while a ketone has at least one C attached to the C=O double bond

The C=O double bond in an aldehyde is adjacent to an alkene, while the C=O double bond in a ketone cannot resonate

The C-O single bond in an aldehyde is protonated, while the C-O single bond in a ketone is not

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Correct answer: An aldehyde has at least one H attached to the C=O double bond, while a ketone has only C attached to the C=O double bond

This means that an aldehyde always appears at the end of a molecule, while a ketone may appear in the middle of a carbon chain. The aldehyde needs only one H adjacent to C=O to be considered an aldehyde, but it is possible to have two adjacent H atoms; this is called "formaldehyde."

5.

What type of bond is **most** commonly found in organic chemistry?

Covalent

Ionic

Coordinate

Hydrogen

Double

Correct answer: Covalent

Organic chemistry overwhelmingly focuses on non-metals: C, H, O, N, P, etc. These atoms are similar enough in terms of electronegativities that they form covalent, rather than ionic, bonds. Hydrogen bonding is important especially for many molecules in biochemistry, but much less common than covalent bonds.

6.

What is unusual about the electron behavior of Cr (Group 6) and Cu (Group 11)?

They prefer to be $4s^1$ rather than $4s^2$

They do not fill the 4s orbital at all

They fill the 4d orbital rather than 3d

They rapidly lose one electron and cannot exist in the unoxidized state naturally

They can form many different oxidation states

Correct answer: They prefer to be $4s^1$ rather than $4s^2$

The rules of electron shells dictate that one subshell gets fully filled before moving onto the next subshell. Cr and Cu are exceptions to this rule. Both are more stable with $4s^1$ than with $4s^2$ because this allows a nice distribution of electrons in their 3d subshell, with exactly one ($3d^5$) or exactly two ($3d^{10}$) electrons in each orbital.

7.

As you proceed down the Group VA column (N, P, As, Sb, Bi), you expect to find all of the following trends, **except:**

Polarizability decreases

Atomic mass increases

Metallic character increases

Electronegativity decreases

Melting point increases

Correct answer: Polarizability decreases

As you move down the column, the atomic radius increases. When electrons are farther away from the nucleus, they are held more loosely and therefore can "slosh around," spending more time on one side or the other of the orbit. This tendency causes decreased electronegativity and increased melting/boiling points.

8.

Of the following hydrocarbons, which would you expect to have the shortest C-C bond length?

C_2H_6, C_2H_4, C_2H_2

C_2H_2

C_2H_4

C_2H_6

All C-C bonds are equivalent in length

The C-C bonds of C_2H_6 and C_2H_4 are equivalent in length; C_2H_2 does not exist

Correct answer: C_2H_2

All of these hydrocarbons can exist because carbon can form single (C_2H_6), double (C_2H_4), and triple (C_2H_2) bonds. The higher the bond order, the shorter the bond.

9.

As you move across a period, what do you expect to happen to atomic radius?

Radius decreases because there are more protons to exert nuclear force

Radius decreases because the atom is less polarizable and more dense

Radius stays about the same because the effect of additional protons cancels out the effect of additional electrons

Radius increases because there are more electrons

Radius increases because there is increased electron shielding

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Correct answer: Radius decreases because there are more protons to exert nuclear force

Though the atoms gain both protons and electrons, it turns out that the effect of one additional proton is greater than the effect of an additional electron in the same electron subshell. Therefore, atomic radius contracts across each period because the additional protons hold the electrons closer together.

10.

What is the most concise name for HIO_3?

Iodic acid

Hydroiodic acid

Iodine trioxic acid

Hydrogen triodic acid

Hydrogen iodine trioxide

Correct answer: Iodic acid

This is part of the oxyacid family, which is named by adding the suffix -ic to the defining element (in this case, iodine). Similarly, $HBrO_3$ is bromic acid and H_3PO_4 is phosphoric acid. Since the hydrogens and oxygens are given, you need to name only the other element!

11.

What is it called when an organic molecule has two C=C double bonds separated by one C—C single bond, such that the entire chain looks like this: C=C—C=C?

Conjugation

Dialkylation

Alkyne

Benzene

Cyclic resonance

Correct answer: Conjugation

Double bonds alternating with single bonds are "conjugated," meaning that they can delocalize electrons over the entire span of the double bonds through resonance.

Benzene is a special kind of cyclic conjugated compound that can delocalize electrons over an entire ring.

12.

Is BrK a valid compound? Why or why not?

No, because it does not comply with standard nomenclature, but KBr would be valid

Yes, because the charges of the ions are balanced

No, because the charges are unbalanced, but Br_2K would be valid

No, because the charges are unbalanced, but BrK_2 would be valid

No, because Br and K differ substantially in electronegativity and would, therefore, form a covalent, not ionic, compound

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Correct answer: No, because it does not comply with standard nomenclature, but KBr would be valid

Standard nomenclature dictates that the positively-charged ion (cation) be written firm, followed by the negatively-charged ion. In this case, K^+ and Br^- form an ionic bond. Ionic and covalent compounds are written according to the same rules; it is up to you to determine, based on the relative electronegativities, whether the bond is ionic or covalent in nature.

13.

Alcohols and ethers both contain oxygen. What is the structural difference?

An alcohol is a terminal -OH; an ether is an O bonded to two C atoms

An alcohol is a terminal -OH; an ether is an O adjacent to a C=O double bond

An alcohol is an O bonded to two C atoms; an ether is a terminal -OH

An alcohol is an O bonded to two C atoms; an ether contains O in a 5- or 6-membered ring

An alcohol occurs off a 5- or 6-membered ring; an ether can occur anywhere

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Correct answer: An alcohol is a terminal -OH; an ether is an O bonded to two C atoms

This difference gives alcohols and ethers very different reactivities. Do not mix ethers up with esters, which contain an O-C single bond that is adjacent to a C=O double bond.

14.

All of the following organic functional groups contain a C=O double bond, **except**:

Ether

Ester

Ketone

Aldehyde

Carboxylic acid

Correct answer: Ether

An ether is comprised of O single-bonded to two C atoms, such that O looks like it is part of an otherwise carbon chain.

15.

What is an allotrope?

One of multiple different physical forms of the same element

An atom that contains a different number of neutrons from another atom of the same type

A compound that can be both acidic and basic

A symmetrical compound

An atom that can lose or gain electrons with equal propensity

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Correct answer: One of multiple different physical forms of the same element

For example, carbon can hybridize with itself in a variety of ways. This leads to substances as different as diamond and graphite: both pure carbon but with very unique physical properties.

16.

Which of the following are acceptable names for HF?

i. Hydrofluoride

ii. Hydrofluoric acid

iii. Hydrogen fluoride

iv. Hydrogen fluorine

ii. and iii.

i., ii., and iii.

i., iii., and iv.

ii. only

i. and ii.

Correct answer: ii. and iii.

HF may be named as a binary compound (hydrogen fluoride) or as a binary acid (hydrofluoric acid). It is useful to be familiar with both types of nomenclature, and use whichever is most appropriate in the context. For example, when discussing acid-base reactions, "hydrofluoric acid" makes the most sense.

17.

Tin (Sn) and lead (Pb) are both Group 14 elements, in the same group as carbon. What oxidation states do you expect them to form readily?

+2 and +4

Any state from -4 to +4

Any state from 0 to +4

-2 and +2

+2 only

Correct answer: +2 and +4

This mirrors the ions that form readily: tin-II, tin-IV, lead-II, and lead-IV. These elements have the valence electron configuration ns^2p^2, so they gain the most stability by losing either two or four electrons.

18.

In which block of the periodic table are you **most** likely to find an element that forms multiple oxidation states?

d-block

s-block

p-block

s-block and p-block equally

p-block and d-block equally

Correct answer: d-block

Transition metals often can form multiple oxidation states, though they usually are most stable in one state consistently. For example, manganese forms every state from -3 to 7 but is most stable in +2.

19.

H_2SO_4 is called sulfuric acid. What is the formula for sulfurous acid?

H_2SO_3

H_2SO_5

H_2SO_2

HSO_4

HSO_3

Correct answer: H_2SO_3

Based on standard nomenclature, the oxyacid with the most oxygen atoms is called the "-ic" acid, while the acid with the next-most oxygen atoms is the "-ous acid." To convert between the formulas, simply add or remove an oxygen.

20.

It is easy to mix up the names of similar compounds. What are the names, in order, of the following nitrogen-containing ions:

NH_4^+, NO_3^-, NO_2^-, N^{3-}

Ammonium, nitrate, nitrite, nitride

Ammonium, nitride, nitrite, nitrate

Ammonium, nitride, nitrate, nitrite

Nitride, ammonium, nitrite, nitrate

Nitride, ammonium, nitrate, nitrite

Correct answer: Ammonium, nitrate, nitrite, nitride

Many sets of similar negative ions contain an -ate, -ite, and -ide. As a general rule, the largest ion ends in -ate, followed by -ite, followed by -ide. For example, SO_4^{2-} = sulfate, SO_3^{2-} = sulfite, and S^{2-} = sulfide.

21.

Rank the following functional groups in terms of increasing bond order (from lowest to highest):

Alkane, Alkene, Alkyne

Alkane < Alkene < Alkyne

Alkane < Alkyne < Alkene

Alkyne < Alkane < Alkene

Alkene < Alkane = Alkyne

Alkyne < Alkene = Alkyne

Correct answer: Alkane < Alkene < Alkyne

These are all carbon-containing compounds. An Alkane contains only single C-C bonds, while an Alkene is a double bond and an Alkyne is a triple bond.

22.

You want to remove an electron from an alkali metal using the least amount of energy possible. How should you choose which metal?

The alkali metal with the largest radius

The alkali metal with the lowest density

The alkali metal with the highest ionization energy

The alkali metal with the highest melting point

The alkali metal with the fewest protons

Correct answer: The alkali metal with the largest radius

The larger the radius, the more loosely held the valence electrons. Francium (the last alkali metal in the column) is, therefore, the easiest to ionize, while lithium is the most difficult (though still quite easy). All other trends lists actually point to the element requiring more, not less, energy to ionize.

23.

Most names of binary compounds don't include any numbers (for example, "aluminum hydroxide," "barium oxide," etc.). So why is "iron(II) chloride" written with a number?

Iron has more than one possible oxidation state

Iron has more than one possible isotope

There are multiple types of the iron element

It is a remnant of an old nomenclature system but doesn't need to be written this way

It is a stylistic preference but doesn't need to be written this way

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Correct answer: Iron has more than one possible oxidation state

Some metals (iron, copper, gold, tin, chromium, mercury, and lead) can form two or even three oxidation states. Since iron can form a 2+ or 3+ ion, the name "iron chloride" could indicate either $FeCl_2$ or $FeCl_3$. We, therefore, include the oxidation state of iron for clarification.

24.

The "alcohol" humans consume is ethyl alcohol or C_2H_6O. Which part of this molecule gives it the "alcohol" in its name?

Terminal -OH

Terminal $-CH_3$

C-C single bond

C-O single bond

Content of two C atoms

Correct answer: Terminal -OH

An "alcohol" is an -OH group located off the carbon chain. The other part of this molecule's name, "ethyl," comes from having two C atoms.

25.

What is the defining feature of an amine?

It is an ammonium derivative in which at least one H has been replaced by an alkyl group

It has a terminal $-NH_3$

It has a terminal $-NH_2CH_3$ or NH_3

It is an ammonium derivative in which 3-4 H atoms have been replaced by an alkyl group

It is an N atom bonded only to C, but not to H

Correct answer: It is an ammonium derivative in which at least one H has been replaced by an alkyl group

If you start with ammonium (NH_4^+) and subject it to alkylation, you can replace H with an alkyl group. This alkyl group may be as simple as a methyl (CH_3) or much more complicated. Furthermore, you can replace each H in succession up to three times. Amines are referred to based on how many N-C bonds they contain: primary (one N-C bond), secondary (two N-C bonds), or tertiary (three N-C bonds).

26.

Based on standard nomenclature, what is $Al(OH)_3$ called?

Aluminum hydroxide

Aluminum trihydroxide

Aluminum oxyhydride

Alumide trihydroxide

Alumide oxyhydride

Correct answer: Aluminum hydroxide

In a binary, metal-ion compound, the metal keeps its name while the ion takes the suffix -ide. It is important to realize that the OH group is the ion hydroxide, and is therefore named as a unit (not as individual atoms, as would be implied by "oxyhydride"). The number of units is not included in the name. It is implied that the compound has a neutral net charge, and since aluminum tends to form the 3+ ion, we can infer that there must be three hydroxide groups with a 1- charge each.

27.

Which set of descriptors **best** describes an element to the left of the stairstep line on the periodic table?

Malleable, ductile, electrical conductor, solid at room temperature

Malleable, brittle, electrical conductor, liquid at room temperature

Brittle, ductile, non-conductor, solid at room temperature

Brittle, non-malleable, electrical conductor, solid at room temperature

Malleable, ductile, non-conductor, liquid at room temperature

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Correct answer: Malleable, ductile, electrical conductor, solid at room temperature

Metals fall to the left of the stairstep line and are generally malleable (can be beaten into sheets without breaking), ductile (can be pulled into wires), and good conductors of electricity. They are all solid at room temperature with the notable exception of mercury (liquid).

28.

Which of the following organic functional groups would you expect to be **most** acidic (lowest pKa)?

Carboxylic acid

Alkane

Alkyne

Aldehyde

Ketone

Correct answer: Carboxylic acid

Carboxylic acid contains a terminal -OH group that loses its proton easily. The resulting negative charge can be stabilized by the adjacent C=O double bond. None of the other answer choices are remotely acidic.

29.

Period 6 is called the:

Actinides

Lanthanides

Allurilides

Lurbidamides

Lacithanides

Correct answer: Actinides

Periods 6 and 7 are the Actinides and the Lanthanides, respectively. They are usually displayed at the bottom of the periodic table and have very different behaviors from the elements toward the top of the periodic table.

30.

When considering ionization energy, some chemists talk about a quantity called "Z_{eff}." What does this mean?

The effective nuclear charge felt by valence electrons

The effective nuclear charge felt by the inner-most electrons

The total number of protons

The number of protons minus the number of electrons

The number of protons plus the number of neutrons

Correct answer: The effective nuclear charge felt by valence electrons

On the periodic table, Z is the number of protons, and A is the atomic mass (roughly, protons + neutrons). Z_{eff} considers the fact that electrons further away from the nucleus cannot feel the full effect of all the protons because inner electrons "shield" the outer ones from the protons' charge. Therefore, Z_{eff} is the nuclear charge experienced by an electron that could potentially leave, and ionization energy increases as Z_{eff} increases.

31.

Groups 3, 4, 5, and 6 are all electropositive transition metals. Which group do you expect to be, on average, the most polarizable? To have the highest melting point?

Group 6 is the most polarizable and has the highest melting point

Group 3 is the most polarizable and has the highest melting point

Group 6 is the most polarizable; Group 3 has the highest melting point

Group 3 is the most polarizable; Group 6 has the highest melting point

None of these groups are at all polarizable

Correct answer: Group 6 is the most polarizable and has the highest melting point

On average, larger atoms are more polarizable because there is a greater distance between the nucleus and the outermost electrons. These electrons are, therefore, less tethered to their orbits and can "slosh around" more, creating a polarized atom. Polarized atoms are, in turn, more attracted to each other than nonpolarized atoms, so greater polarizability leads to stronger intermolecular forces and a higher melting point.

32.

Based on standard nomenclature, what is LiF called?

Lithium fluoride

Lithium fluorine

Lithium fluorox

Lithide fluoride

Lithide flourine

Correct answer: Lithium fluoride

In a binary, metal-nonmetal compound, the metal keeps its name while the nonmetal takes the suffix -ide.

33.

Does oxygen react well with metals?

Yes, it reacts with almost all metals

Yes, it reacts vigorously with all metals

Yes, it reacts with metals to form peroxides

No, it reacts vigorously with alkali metals, but those are an exception

No, it does not react much with any metals

Correct answer: Yes, it reacts with almost all metals

Oxygen reacts to some extent with almost all metals; the exceptions are gold and platinum. Most metals form oxides when exposed to oxygen (this is why metal "rusts").

34.

What is the formula of barium hydroxide?

- **$Ba(OH)_2$**
- BaOH
- Ba_2OH
- BaH_2O
- $Ba(H_2O)_2$

Correct answer: $Ba(OH)_2$

It is important to know that the barium ion carries a 2+ charge (as is common for Group IIA elements), while hydroxide carries a 1- charge. The compound must, therefore, contain one Ba and two OH groups.

35.

The "Chalcogen" family is synonymous for:

Group 16 / VIA

Group 17 / VIIA

Group 18 / VIIIA

Group 1 / IA

Group 2 / IIA

Correct answer: Group 16 / VIA

Variably known as the chalcogens, Group 16, and the oxygen family, this column contains O, S, Se, Te, and Po.

36.

Fluorine is the smallest halogen atom. Compared with its larger halogen peers (Cl, Br, and I), how do you expect fluorine to behave in terms of redox and acid-base tendencies?

Fluorine is the strongest oxidant; hydrofluoric acid is the weakest acid

Fluorine is the strongest reductant; hydrofluoric acid is the weakest acid

Fluorine is the weakest oxidant; fluoride is the strongest base

Fluorine is the strongest oxidant; hydrofluoric acid is the strongest acid

Fluorine is the weakest reductant; fluoride is the weakest base

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Correct answer: Fluorine is the strongest oxidant; hydrofluoric acid is the weakest acid

Like all halogens, fluorine is only one electron away from a full octet. Fluorine's small size makes it especially difficult to stabilize this condition, so out of all the halogens, fluorine is the most determined to hold the 8th electron. It can do this by oxidizing another atom (and thereby becoming reduced itself), or by bonding with an atom like hydrogen (so it is relatively reluctant to give up that proton).

37.

Element M is a mystery element that belongs to Group 3. Predict the products of M reacting with water and don't worry about balancing the equation:

$M_{(s)} + H_2O_{(l)} \rightarrow ??$

$M(OH)_{3\ (s)} + H_{2\ (g)}$

$MOH_{(s)} + H_{2\ (g)}$

$MO_{2\ (g)} + H_{2\ (g)}$

$MOH_{(s)} + O_{2\ (g)}$

$M(OH)_{3\ (s)} + O_{2\ (g)}$

Correct answer: $M(OH)_{3\ (s)} + H_{2\ (g)}$

Group 3 elements all preferentially form the 3+ oxidation state by giving up all three valence electrons. When exposed to water, they, therefore, oxide and release hydrogen gas, just like many other metals.

38.

Where on the periodic table do you expect to find consistently high ionization energies?

Group VIIIA / Group 18

Group IA / Group 1

Period 1

Period 7

f-block

Correct answer: Group VIIIA / Group 18

Ionization energy is the energy required to remove an electron from the valence shell. In other words, it measures how tightly an atom holds onto its electrons. The noble gases (Group VIIIA / 18) have full octets and are, therefore, very stable and very resistant to giving up an electron.

39.

In organic chemistry, what does "resonance" mean?

Delocalization of electrons between multiple atoms/bonds

Vibrations within a bond

Delocalization of electrons across an entire molecule

Vibrations within an entire molecule

Delocalization of negative charge across multiple atoms

Correct answer: Delocalization of electrons between multiple atoms/bonds

Electrons may be delocalized between two or more entities and require double bonds to allow these electrons to pass fluidly between multiple atoms. Resonance functions may distribute positive or negative charge, helping to stabilize the molecule.

40.

Sometimes, elements are referred to by their s-, p-, d-, and f-blocks based on the highest subshell they contain. Which elements would be contained in the s-block?

Alkali metals and alkaline earth metals

Alkali metals only

Metals

Transition metals and non-metals

Non-metals only

Correct answer: Alkali metals and alkaline earth metals

The s-block contains the two left-most columns on the periodic table, or Group IA (Alkali metals) and Group IIA (alkaline earth metals).

41.

From top to bottom, Group IIA on the periodic table contains Be, Mg, Ca, St, Ba, and Ra. Which is the **most** metallic?

Ra

Be

Mg

Be and Mg are approximately equal

Ba and Ra are approximately equal

Correct answer: Ra

Within the same group/family, metallic character increases with atomic number. Radon has the highest atomic number and is, therefore, the most metallic! The opposite is true with non-metallic character.

42.

Melting and boiling points vary widely across the periodic table and do not form trends that are as consistent as other traits. Which of the following is a reasonable generalization about melting/boiling point trends?

Most non-metals have lower melting boiling points

Noble gases have higher boiling points

All metals have melting points above room temperature

Smaller atoms have higher melting and boiling points

More polarizable atoms have lower melting points

Correct answer: Most non-metals have lower melting points

Though there are a few exceptions (like carbon), non-metals generally melt and vaporize at much lower temperatures than metals do. Consider the fact that all metals except for mercury are solid at room temperature (mercury is a liquid). In general, melting/boiling points are higher when there are stronger intermolecular attractions. Therefore, noble gases have very low points while larger, polarizable atoms have higher points.

43.

"Aurous chloride" in old nomenclature is equivalent to what in current nomenclature?

Gold(I) chloride

Gold(II) chloride

Gold(III) chloride

Monogold chloride

Bigold chloride

Correct answer: Gold(I) chloride

In old nomenclature, there are special suffixes for metals with multiple oxidation states. The suffix -ous is applied to the lower oxidation state (in this case, gold(I) = aurous) while the suffix -ic is applied to the higher oxidation state (for example, gold(III) = auric).

44.

Which two periodic trends follow exactly the same pattern?

Ionization energy and electronegativity

Ionization energy and atomic radius

Atomic radius and metallic character

Electronegativity and number of valence electrons

Number of valence electrons and metallic character

Correct answer: Ionization energy and electronegativity

Both ionization energy and electronegativity increase across each row and up each column. This should make intuitive sense: ionization energy is the energy required to remove an electron from the atom, while electronegativity is the tendency to gain another electron. These are influenced by the same forces.

45.

Based on standard nomenclature, what is the name for SO_3?

Sulfur trioxide

Sulfur oxide

Monosulfur trioxide

Sulfous oxide

Sulfous trioxygen

Correct answer: Sulfur trioxide

When naming pairs of nonmetallic elements, keep the name of the first element (written first because it is more metallic) and add the suffix -ide to the second element. Indicate numbers with prefixes (mono-, di-, tri, etc.). The prefix can be dropped from the first element if it is singular (so "monosulfur" becomes "sulfur").

46.

In organic chemistry, what is an alkane?

A molecule with C-C single bonds and C-H single bonds

A molecule with C-C double bonds

A molecule with O bonded to two C atoms, both with single bonds

A molecule with N bonded to one, two, or three C

A molecule with a C-O double bond

Correct answer: A molecule with C-C single bonds and C-H single bonds

An alkane is the simplest organic molecule, consisting of a chain with any number of C-C bonds. Do not confuse this with alkene (C-C double bond) or alkyne (C-C triple bond).

47.

Where on the periodic table would you look for the **least** electronegative element?

- **Bottom left**
- Top left
- Top right
- Bottom right
- Anywhere along the bottom row

Correct answer: Bottom left

Electronegativity increases across each row (so fluorine is more electronegative than lithium) and up each column (so lithium is more electronegative than francium). As you move across a row, the valence shell gets closer to full, so the atom has increasingly more to gain from obtaining another electron. As you move up a column, atomic radius decreases, so the positive force of the nucleus is better able to attract additional electrons. Combined, these trends make fluorine (top right) the most electronegative, while francium (bottom left) is the least electronegative.

48.

Which two organic functional groups are found in all amino acids?

Amine and carboxylic acid

Amine and alcohol

Primary amine and secondary amine

Carboxylic acid and alcohol

Alcohol and ether

Correct answer: Amine and carboxylic acid

The name "amino acid" reflects the composition of an amine and a carboxylic acid. These functional groups can bond with each other, allowing many amino acids to be strung together in "polypeptides" that make up proteins.

49.

In which of the following groups would you expect to find the widest range of physical properties and chemical behaviors?

Group 14

Group 1 (alkali metals)

Group 2 (alkaline earth metals)

Group 5

Group 18 (noble gases)

Correct answer: Group 14

This group contains a non-metal (carbon), metalloid (silicon), and several metals, creating a huge variety of properties within the same group. In contrast, many groups have similar properties throughout the periodic table.

50.

Which of the following are binary compounds?

i. CaO

ii. NH_4^+

iii. KOH

i. and iii.

i. only

i. and ii.

iii. only

i., ii., and iii.

Correct answer: i. and iii.

A binary compound usually contains two elements, such as Ca and O in calcium oxide. However, for the sake of naming, common ion groups such as ammonium (NH_4^+), hydroxide (OH^-), and cyanide (CN^-) are treated as a single group. Therefore, KOH ("potassium hydroxide") is considered a binary compound, while NH_4^+ (ammonium ion) is not. It is useful to be familiar with the formulas and nomenclature of common ion groups.

51.

Rubidium is an alkali metal and is often stored in a vial with argon gas (a noble gas). Why might this be a good idea?

Rubidium would oxidize quickly if exposed to oxygen in the air

Rubidium is highly magnetic and should be secured in a container to avoid damaging lab equipment

Rubidium is extremely conductive and could create a current around it in the air

Argon makes rubidium look particularly shiny

Argon reacts slowly with rubidium, increasing its value

Correct answer: Rubidium would oxidize quickly if exposed to oxygen in the air

Like all other alkali metals, rubidium quickly gives up its valence electron to oxygen in the air. Therefore, if you want to preserve a rubidium sample, you should prevent it from contacting oxygen. This can be accomplished by storing it in oil or in an inert gas like argon.

52.

If a carboxylic acid has the -OH replaced with Br, what is this new class of functional group called?

Acid halide

Keto halide

Carboxyl halide

Halidoketone

Halic acid

Correct answer: Acid halide

An acid halide is created by using a halide (Br, Cl, I) to replace the hydroxy-group of a carboxylic acid. They are named similarly to the original carboxylic acid, replacing the -ic suffix with -yl. For example, if propanoic acid were converted into an acid halide with bromine, it would be named propanoyl bromide.

53.

If a halogen is exposed to a main group element (for example, an element in Group 1, 2, 13, or 14), what do you expect will form?

Salt

Gas

Liquid

Acid

Base

Correct answer: Salt

Remember that "halogen" means "salt former." These elements gain stability by being reduced, and they often gain an electron from an electropositive compound. This creates an ionic bond, or a salt.

54.

All noble gases have high ionization energies because the loss of one electron is very destabilizing. If you had to try to use the minimum possible energy to remove an electron from one noble gas, how would you decide which gas to work with?

The one with the largest atomic radius

The one with the fewest protons

The one with the greatest electronegativity

The one with the most neutrons

The one with the least metallic character

Correct answer: The one with the largest atomic radius

As the atomic radius increases, the valence electrons are farther and farther away from the nucleus. Since the nucleus contains the protons, it is also the source of the electrostatic forces that keep the electrons tethered to the atom. These forces weaken with distance, so larger atoms hold their valence electrons more loosely.

55.

Oxygen appears to the right of boron in the periodic table. Which has greater electronegativity (EN)? Which has greater ionization energy (IE)?

Oxygen has greater EN and IE

Boron has greater EN and IE

Oxygen has greater EN, while boron has greater IE

Boron has greater EN, while oxygen has greater IE

Since they are in the same row, they have approximately the same EN and IE

Correct answer: Oxygen has greater EN and IE

EN and IE follow the same trend: both increase as you move across each row and up each column. Oxygen and boron are in the same period (row), but since oxygen is further across that row, it has greater EN and IE. In practical terms, this means it is more likely to gain an electron and also holds more tightly to the electrons it already has.

56.

What are the Group VIIA elements most commonly known as?

Halogens

Noble Gases

Metalloids

Alkali metals

Transition metals

Correct answer: Halogens

Group VIIA contains elements like fluorine, chlorine, bromine, and iodine, which react readily with alkali metals to form salts. "Halogen" means "salt-former"!

57.

Which group is most commonly found in the diatomic form (i.e., X_2)?

Halogens

Noble gases

Chalcogens

Transition metals

Alkali metals

Correct answer: Halogens

By bonding with themselves (i.e., F_2, Cl_2, Br_2), halogens complete their octets and form stable gases. A few non-halogens form diatomic molecules as well: N, O, H.

58.

Though hydrogen is displayed above the alkali metals on the periodic table, it is in many ways different from the alkali metals. All of the following differences between hydrogen and alkali metals are true, **except**:

Hydrogen does not have the valence shell configuration ns^1

Hydrogen is more reluctant to ionize

Hydrogen is a nonmetal

Hydrogen readily bonds with itself

Hydrogen forms covalent bonds more readily

Correct answer: Hydrogen does not have the valence shell configuration ns^1

Hydrogen's valence electron configuration looks like that of the alkali metals: Hydrogen is $1s^1$, Li is $2s^1$, Na is $3s^1$, etc. However, hydrogen is more electronegative than the alkali metals. This makes it more difficult to ionize (H+ forms less readily than Na+, Li+, etc.) but easier to form covalent bonds with itself and others (H_2 exists, Na_2 does not).

59.

Sodium (Na) and potassium (K) are both members of Group IA. Sodium reacts vigorously in water. How would you expect potassium to behave in water?

React vigorously, like sodium

React, but not to the same extent as sodium does

React more vigorously than sodium does

Not react at all

Impossible to say with the information given

Correct answer: React vigorously, like sodium

Groups (also known as “families”) contain elements with similar chemical properties. With the exception of hydrogen, all members of Group IA (the left-most column in the periodic table) react vigorously with water to form an alkaline solution.

60.

Group IIA, or the second left-most column in the periodic table, contains what type of elements?

Alkaline earth metals

Alkali metals

Transition metals

Metalloids

Noble gases

Correct answer: Alkaline earth metals

Group IA contains alkali metals, while IIA contains alkaline earth metals. When oxidized, these elements react in water to form alkaline solutions. In contrast, noble gases are found on the right-most column and are inert (don't react with anything).

61.

In organic chemistry, a circular molecule with electrons that can move freely between all orbitals is called:

Aromatic

Alkene

Amide

Anhydride

Aldehyde

Correct answer: Aromatic

For example, benzene is a six-membered carbon ring that has resonance (alternating single and double bonds) all the way around the ring. This resonance allows some of the electrons to freely transverse the orbitals, creating interesting bonding properties.

62.

$HClO_3$ is chloric acid and $HClO_2$ is chlorous acid. What is the name of HClO?

Hypochlorous acid

Hypochloric acid

Hyperchloride

Hyperchlorite acid

Hyperchloroxide

Correct answer: Hypochlorous acid

For oxyacids, the compound with the most oxygen atoms is the "-ic acid," followed by the "-ous acid" and finally the "hypo- -ous acid."

63.

All of the following are considered organic molecules, **except**:

CN^-

C_2H_6

C_2H_5OH

$C_{10}H_{11}ClN_4$

$C_{22}H_{14}N_6Na_2O_9S_2$

Correct answer: CN^-

Though the cyanide ion (CN^-) does contain carbon covalently bonded to another non-metal, it is not considered organic. Organic molecules usually contain hydrogen in addition to carbon; if there are other atoms (such as Cl or S), they are the overwhelming minority. The "nitrile" is an organic functional group that is essentially cyanide (CN, with a triple bond) but is connected to a larger molecule with a C-C single bond.

64.

Consider just the first two columns of the periodic table (alkali metals and alkaline earth metals, excluding hydrogen). Where do you expect to find the **most** electronegative element?

First element of the alkaline earth metals

First element of the alkali metals

Last element of the alkaline earth metals

Last element of the alkali metals

Any of the alkali metals are about the same

Correct answer: First element of the alkaline earth metals

The trends in these two columns mirror the trends for the entire periodic table. Electronegativity increases to the right (as the valence shell fills) and up (as the electrons are held closer to the nucleus).

65.

Xenon is located to in the right-most column on the periodic table. What categories does xenon belong to?

Nonmetal, noble gas

Metal, noble gas

Metalloid, halogen

Nonmetal, halogen

Metalloid, noble gas

Correct answer: Nonmetal, noble gas

Elements to the right of the stairstep line are considered nonmetals (with the exception of a few elements that fall immediately along the line). The right-most column, also known as Group VIIIA, are the noble gases. These elements are inert (don't react with any other elements).

66.

Which of the following electrons is experiencing the **greatest** effective nuclear charge (Z_{eff})?

A 2p electron in an atom with 9 protons

A 2p electron in an atom with 6 protons

A 3s electron in an atom with 12 protons

A 4p electron in an atom with 35 protons

A 5s electron in an atom with 37 protons

Correct answer: A 2p electron in an atom with 9 protons

The effective nuclear charge is determined by the number of protons (more protons = more charge) and the shielding effects of other electrons (more shielding = less charge). Therefore, 2p electrons will feel the nuclear charge more acutely than will electrons that are farther away (3s, 4p, 5s). The 2p electron will feel the most charge when it is near 9, rather than 6, protons.

67.

What are the **most** fundamental building blocks of organic chemistry?

- **C and H**
- C and O
- O and H
- C and P
- P, H, and O

Correct answer: C and H

"Organic" molecules are often thought of (simplistically) as "carbon-containing compounds." The vast majority also contain hydrogen, and many more contain oxygen, nitrogen, and sometimes phosphorous.

68.

Many elements can form hydrides by bonding with hydrogen (for example, HF, H_2Se, SnH_4). Most of these compounds have very similar boiling points, but there are three exceptions with surprisingly elevated boiling points: H_2O, NH_3, and HF. Why?

N, O, and F are particularly electronegative

These compounds contain covalent, rather than ionic, bonds

N, O, and F have a particularly non-metallic character

These compounds are strong acid

These compounds are much smaller than most hydrides

Correct answer: N, O, and F are particularly electronegative

These elements are so electronegative that they create a highly polarized molecule when bonded to hydrogen. This allows for hydrogen bonding between molecules, increasing intermolecular forces and elevating the boiling point.

The smallness of these compounds would suggest a low, not a high, boiling point. Though they do contain covalent bonds, so do many other hydrides with lower boiling points. They are only weakly acidic, and acidity is unrelated to boiling point.

69.

Consider Period 3 (ranges from Na to Ar), most of which readily forms oxides. Which element(s) would you **not** expect to form an oxide?

The noble gas (Ar)

The alkali metal (Na)

The alkaline earth metal (Mg)

The transition metal (Al)

The halogen (Cl)

Correct answer: The noble gas (Ar)

Argon does not react with oxygen because it is a noble gas; it does not react with anything. All other elements in this period react with oxygen to form oxides.

70.

If you were instructed to name all the elements in a specific period, where on the periodic table would you look?

A single row

A single column

A group of columns

A cluster of elements in the center of the table

A cluster of elements in the right-hand side of the table

Correct answer: A single row

In the periodic table, rows are called “periods” and columns are called “groups.” All the elements in a single period are similar in terms of atomic number and mass but will vary significantly in other properties. Most of the time, we focus on groups (also called “families”) because elements within the same group/family have similar chemical properties.

Equations and Stoichiometry

71.

When balancing an ionic equation, which chemical species should be included in the equation?

Only the species that participate in oxidation/reduction

Only the solutes, not the solvents

Only the ions, not the neutral compounds

All solutes and gases, not pure solids and liquids

All species that are present should be included

Correct answer: Only the species that participate in oxidation/reduction

Since you start the balancing process by writing half-reactions, it should be easy to figure out which species do and do not have changes in oxidation states. You may additionally add water and protons to the equations as sources of oxygen and hydrogen.

72.

What is the fundamental difference between a molecular formula and an empirical formula?

A molecular formula represents the actual number of atoms in a molecule, while an empirical formula represents the most simplified ratio of atoms in the molecule

A molecular formula represents only covalent compounds, while an empirical formula can represent ionic or covalent compounds

A molecular formula represents any chemical compound, while an empirical formula represents only a compound that is demonstrably reactive in a lab

A molecular formula is used to discuss the general properties of a compound, while an empirical formula is used to discuss specific reactivities

There is no difference between a molecular formula and an empirical formula (the terms are interchangeable)

Correct answer: A molecular formula represents the actual number of atoms in a molecule, while an empirical formula represents the most simplified ratio of atoms in the molecule

For example, the molecular formula of glucose is $C_6H_{12}O_6$ while the empirical formula is CH_2O. The latter version is called the "empirical formula" because it is easier in the lab to determine empirically the ratio of atoms in a compound. It is more difficult to arrive at the molecular formula.

73.

$Fe_2O_{3\ (s)} + CO_{(g)} \rightarrow Fe_{(s)} + CO_{2\ (g)}$

How much iron (Fe) is produced from 20g iron oxide (Fe_2O_3), assuming that carbon monoxide (CO) is in excess?

Molar masses: Fe=55.86, O=16.00, C=12.01

13.99g

6.99g

10g

8.74g

11.82g

Correct answer: 13.99g

First, balance the equation to determine the stoichiometric ratios: $Fe_2O_{3\ (s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2\ (g)}$

Then, use dimensional analysis:

*(20g Fe_2O_3) * (1mol Fe_2O_3 / 159.72g Fe_2O_3) * (2mol Fe / 1mol Fe_2O_3) * (55.86g Fe / 1mol Fe) = 13.99g Fe*

74.

When balancing ionic equations, when should you add OH- (hydroxide) ions to balance out the H+ (protons) to form water?

When the reaction occurs in basic solution

When the reaction occurs in acidic solution

When spectating ions contain OH-

Always

Never

Correct answer: When the reaction occurs in basic solution

In basic solution, you can assume the presence of free hydroxide ions in solution. These would logically combine with protons to form water, so you can use them for the sake of balancing your equation. In contrast, acidic solutions have an abundance of protons, so you should assume that any protons you use to balance the equation will remain free in solution.

75.

What is the limiting reagent in the following reaction?

$Pb(OH)_4 + 2H_2SO_4 \rightarrow Pb(SO_4)_2 + 4H_2O$

Impossible to tell

$Pb(OH)_4$

H_2SO_4

$Pb(SO_4)_2$

H_2O

Correct answer: Impossible to tell

The limiting reagent involves the actual quantities that you have of each substance, rather than any information you can glean from the equation itself.

76.

Write the following word equation in appropriate chemical symbols:

sodium hydroxide plus hydrochloric acid yields sodium chloride plus water

$NaOH + HCl \rightarrow NaCl + H_2O$

$NaOH + HClO \rightarrow NaClO + H_2O$

$Na(OH)_2 + HCl \rightarrow NaCl_2 + H_2O$

$Na(OH)_2 + HClO \rightarrow Na(ClO)_2 + H_2O$

$NaOH + H_2Cl \rightarrow NaCl + H_2O$

Correct answer: $NaOH + HCl \rightarrow NaCl + H_2O$

It is helpful to know that all ions involved in this reaction are +1 or -1 ions, so only one of each is needed. The correct equation is already balanced.

77.

When balancing ionic equations, you are taught to write "half-reactions." On what basis do you divide the reaction in half?

Oxidation/reduction

Reactants/products

Acids/bases

Metals/non-metals

Ionic/covalent

Correct answer: Oxidation/reduction

You will write one reaction that contains the oxidation process and a separate reaction that contains the reduction process. Once atoms and charge are balanced, you re-combine the equations for the final result.

78.

In the following chemical formula, how many atoms of each species are present?

$3Ba(OH)_2$

Three Ba, six O, six H

Three Ba, two O, two H

Three B, three a, six O, six H

Three B, three a, two OH

Three Ba, two OH

Correct answer: Three Ba, six O, six H

The atoms involved here are Ba (barium), O (oxygen), and H (hydrogen). Remember that atomic symbols may come as a single capital letter or a pair of letters (one capital, one lower case). Once you have identified the atoms correctly, remember that the coefficient (in this case, 3) applies to the entire molecule. The subscript (in this case, 2) applies only to the atom or set of parenthesis preceding it.

79.

Consider this equation: $Al + O_2 \rightarrow Al_2O_3$

Which version is balanced appropriately?

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$Al + O_2 \rightarrow Al_2O_3$

$2Al + 1.5O_2 \rightarrow Al_2O_3$

$2Al + O_2 \rightarrow Al_2O_3$

$8Al + 6O_2 \rightarrow 4Al_2O_3$

Correct answer: $4Al + 3O_2 \rightarrow 2Al_2O_3$

This uses the simplest possible whole number coefficients. When balancing equations, make sure that you have the same number of each element on both sides (in this case, 4 Al and 6 O) and that you have simplified the ratio of coefficients.

80.

What is the **first** step in balancing net ionic equations?

Write the half-reactions

Balance all atoms except for C, H, and O

Balance all atoms except for O and H

Balance O and H by adding H_2O and H+ as needed

Add electrons to one side or the other to balance charge

Correct answer: Write the half-reactions

It is best to work with net ionic equations by considering their component parts: oxidation and reduction. Once you balance atoms and charge within the half-reactions, you can add the equations together for the final product.

81.

What coefficients would balance the following equation?

__$(NH_4)_3PO_4$ + __$Pb(NO_3)_4$ → __$Pb_3(PO_4)_4$ + __NH_4NO_3

4, 3, 1, 12

4, 3, 1, 3

1, 3, 1, 4

8, 6, 1, 12

1, 1, 1, 3

Correct answer: 4, 3, 1, 12

Since NH_4 and NO_3 consistently travel together, it is easiest to balance this equation by considering these as single units rather than accounting for N, H, and O separately.

82.

Balance the following chemical equation. What are the appropriate coefficients (in order)?

__$Pb(OH)_4$ + __H_2SO_4 → __$Pb(SO_4)_2$ + __H_2O

1, 2, 1, 4

1, 2, 1, 1

1, 2, 1, 2

2, 4, 2, 8

1, 1, 1, 4

Correct answer: 1, 2, 1, 4

Though 2, 4, 2, 8 is technically balanced as well, chemical equations should always be written with the lowest possible coefficients (unless specified otherwise).

83.

What is the net ionic equation for the following reaction?

$AgNO_{3(aq)} + KCl_{(aq)} \rightarrow AgCl_{(s)} + KNO_{3(aq)}$

$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$

$AgNO_{3(aq)} + KCl_{(aq)} \rightarrow AgCl_{(s)}$

$Ag^{+}_{(aq)} + NO_3^{-}{}_{(aq)} + K^{+}{}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)} + K^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$

$NO_3^{-}{}_{(aq)} + K^{+}{}_{(aq)} \rightarrow KNO_{3\,(aq)}$

$AgNO_{3\,(aq)} + K^{+}{}_{(aq)} \rightarrow KNO_{3\,(aq)}$

Correct answer: $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$

To write the net ionic equation, you can first write the total ionic equation by separating soluble ions into their constituent parts:

$Ag^{+}_{(aq)} + NO_3^{-}{}_{(aq)} + K^{+}{}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)} + K^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$

Then eliminate the spectator ions (those that are present on both sides of the equation, in this case K^{+} and NO_3^{-}).

84.

Consider the left side of an equation:

$3Ba(OH)_2 + H_2O + NaCl \rightarrow ?$

Before you balance the equation, you would need to account for the number of atoms on each side. How many H and O atoms are on the left side?

8H, 7O

8H, 8O

5H, 4O

4H, 3O

12H, 11O

Correct answer: 8H, 7O

Be careful to include coefficients and subscripts when tallying atoms. Once you determined the products, you would need to balance the equation to ensure that there is the same number of each type of atom on both sides.

85.

What is the difference between a complete ionic equation and a net ionic equation?

The complete ionic equation contains all dissociated ions in a reaction; the net ionic equation contains only the ions that participate in the reaction

The complete ionic equation contains all dissociated ions in a reaction; the net ionic equation contains only the atoms that change oxidation states

The complete ionic equation contains only the ions that participate in the reaction; the net ionic equation contains all aqueous and solid state ions

The complete ionic equation is balanced with actual coefficients; the net ionic equation contains the lowest possible ratio of coefficients

The complete ionic equation is not balanced; the net ionic equation is balanced

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Correct answer: The complete ionic equation contains all dissociated ions in a reaction; the net ionic equation contains only the ions that participate in the reaction

When soluble compounds are placed in solution together, some of the dissociated ions may react while others may "spectate." Net ionic equations are useful because they eliminate "spectator ions," allowing you to focus on the reaction at hand.

86.

What is wrong with the following equation?

$Na_{(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_{2(g)}$

It is not written as a balanced equation

It should have a double-ended (equilibrium) arrow

It should take place entirely in aqueous solution

It cannot take place in aqueous solution

It involves improbable oxidation states

Correct answer: It is not written as a balanced equation

There is nothing chemically wrong with this equation. However, as written, there is only one H atom on the left and two H atoms on the right. The balanced equation is:

$2Na_{(s)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_{2(g)}$

87.

What coefficients would balance the following reaction?

__FeS + __O_2 → __Fe_2O_3 + __SO_2

4, 7, 2, 4

2, 7, 2, 4

4, 6, 3, 2

2, 7, 1, 4

2, 5, 3, 2

Correct answer: 4, 7, 2, 4

This reaction is challenging because oxygen appears so many times. Start with the non-oxygen atoms:

2FeS + __O_2 → __Fe_2O_3 + 2SO_2

Now there are only two oxygens on the left but seven on the right. Therefore, to be balanced, the reaction requires 14 oxygens on either side (14 is the least common multiple of 2 and 7):

2FeS + 7O_2 → 2Fe_2O_3 + 4SO_2

This adjustment increased the number of Fe and S, so the last step is to adjust this:

4FeS + 7O_2 → 2Fe_2O_3 + 4SO_2

88.

Which of the following is the **correct** way to double the formula for water?

$2H_2O$

H_4O_2

H_2O_2

$2(H_2)O$

H_4O_4

Correct answer: $2H_2O$

When balancing equations, increase the number of molecules by placing a coefficient in front of the formula. It's important to avoid changing the molecular formula when balancing equations!

89.

$H_2O_2 \rightarrow H_2O + O_2$

What volume O_2 gas is produced from 1.90mol H_2O_2 at STP?

21.3L

42.6L

28.4L

37.9L

11.0L

Correct answer: 21.3L

First, balance the equation: $2H_2O_2 \rightarrow 2H_2O + O_2$

At STP, all gases can be assumed to occupy 22.4L/mol. Therefore:

*(1.90mol H_2O_2) * (1mol O_2 / 2mol H_2O_2) * (22.4L O_2 / 1mol O_2) = 21.3L O_2*

90.

What would be a reasonable first step in balancing the following equation?

$Pb(OH)_4 + H_2SO_4 \rightarrow Pb(SO_4)_2 + H_2O$

Any of these

Adjust the coefficient of H_2SO_4

Adjust the coefficient of H_2O

Create a table to track each element on both sides of the reaction

None of these

Correct answer: Any of these

There are many ways to balance reactions, all of which can produce the correct final answer. Some people find it helpful to write a tracking table; others can keep count in their heads. In this equation, it would be reasonable to start with the unequal numbers of S, H, or O and go from there.

91.

What coefficients would balance the following equation?

__PCl_5 + __H_2O → __H_3PO_4 + __HCl

1, 4, 1, 5

1, 3, 2, 5

1, 6, 4, 5

2, 4, 2, 10

2, 4, 3, 5

Correct answer: 1, 4, 1, 5

Start by balancing the atoms that appear only once on both sides of the equation:

PCl_5 + H_2O → H_3PO_4 + 5HCl

Then balance the hydrogen and oxygen atoms accordingly:

PCl_5 + 4H_2O → H_3PO_4 + 5HCl

92.

How many oxygen atoms are present in $4Cr(NO_3)_3$?

- **36**
- 3
- 9
- 12
- 27

Correct answer: 36

Pay attention to coefficients and subscripts. Coefficients apply to every atom in the molecule that follows (i.e., there are 4 Cr, 12 N, and 36 O). Subscripts apply only to the atom that precedes the subscript, or to everything inside the parenthesis preceding the subscript.

93.

What coefficients would balance the following chemical equation?

__BF_3 + __Li_2SO_3 → __$B_2(SO_3)_3$ + __LiF

2, 3, 1, 6

2, 1, 1, 6

3, 2, 2, 6

3, 1, 2, 3

6, 3, 1, 2

Correct answer: 2, 3, 1, 6

If you notice that one unit seems to travel together (in this case, SO_3), it may be easier to think of this as a single unit for the sake of balancing the equation. It will also work to think about individual atoms of S and O, but this is more complicated.

94.

What coefficients would balance the following chemical equation?

__KNO_3 +__H_2CO_3 →__K_2CO_3 +__HNO_3

2, 1, 1, 2

2, 1, 1, 1

4, 2, 2, 4

2, 3, 4, 4

2, 3, 1, 2

Correct answer: 2, 1, 1, 2

Though 4, 2, 2, 4 technically balances the equation, it does not do so with the lowest possible coefficients.

95.

You conduct the following reaction in a closed reaction chamber:

$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$

At the end of the experiment, you have collected 18.43g water vapor (H_2O). You want to determine the limiting reagent. Do you need any more information?

Yes, the starting amount of either CH_3OH or O_2

Yes, the starting amounts of both CH_3OH and O_2

Yes, the moles of water vapor produced

Yes, the amount of CO_2 produced

No, it can be determined with the information given

Correct answer: Yes, the starting amount of either CH_3OH or O_2

With either quantity, you can determine how much water vapor could have been produced on the basis of that reactant alone. If the answer is 18.43, then that reactant was limiting; the reaction stopped as soon as it ran out. If the answer is >18.43, then the other reactant must have been limiting.

96.

When balancing an equation, do you need to consider any factors beyond the numbers of each type of atom?

Yes, the charge on both sides of the equation

Yes, the number of molecular species on both sides of the equation

Yes, the number of bonds on both sides of the equation

Yes, the chemical states on both sides of the equation

No

Correct answer: Yes, the charge on both sides of the equation

There must be the same net charge on both sides of the equation. This is especially important if you are working with redox reactions.

97.

In the following equation, NO_3^- and K^+ are both examples of:

$Ag^+_{(aq)} + NO_3^-{}_{(aq)} + K^+{}_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)} + K^+{}_{(aq)} + NO_3^-{}_{(aq)}$

i. Highly soluble ions

ii. Cations

iii. Spectator ions

iv. Aqueous species

i., iii., and iv.

i. and iv.

iii. and iv.

ii. and iv.

i., ii., and iii.

Correct answer: i., iii., and iv.

NO_3^- is an anion (negatively charged) while K^+ is a cation (positively charged). They are both soluble when combined with almost any other ion, which allows them to remain dissolved in most aqueous (water) solutions. In this case, they do not participate in the net reaction (formation of a precipitate), so they are considered spectator ions.

98.

The following equation is an example of:

$Ag^{+}_{(aq)} + NO_3^{-}{}_{(aq)} + K^{+}{}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)} + K^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$

Total ionic equation

Net ionic equation

Molecular equation

Empirical equation

Equilibrium

Correct answer: Total ionic equation

A total ionic equation reports all aqueous ions in a solution, whether or not they actively participate in any reaction. Here, NO_3^- and are K^+ "spectator ions," meaning that they do not participate in the formation of precipitate. They would be excluded from the net ionic equation.

99.

What is the final balanced equation for the following reaction, occurring in basic solution?

$Cr(OH)_3 + Br_2 \quad CrO_4^{2-} + Br^-$

$10OH^- + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^{2-} + 8H_2O + 6Br^-$

$2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^{2-} + 6Br^-$

$2H_2O + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^{2-} + 4H^+ + 6Br^-$

$5OH^- + Cr(OH)_3 + Br_2 \rightarrow CrO_4^{2-} + 4H_2O + 2Br^-$

$H_2O + Cr(OH)_3 + Br_2 \rightarrow CrO_4^{2-} + 2H^+ + 3Br^-$

Correct answer: $10OH^- + 2Cr(OH)_3 + 3Br_2 \rightarrow 2CrO_4^{2-} + 8H_2O + 6Br^-$

The half reactions are below. Note that H_2O and OH^- are used to balance the reactions because this occurs in basic solution.

$2e^- + Br_2 \rightarrow 2Br^-$ (reduction)

$5OH^- + Cr(OH)_3 \rightarrow 3e^- + 4H_2O + CrO_4^{2-}$ (oxidation)

Multiply the reduction by 3 and the oxidation by 2 to balance the number of electrons transferred. Add the half-reactions together to get the final result.

100.

What is wrong with the following ionic equation?

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

Na and Cl should not be included

H_2O should not be included

The reaction would not occur because HCl is a weak electrolyte

NaCl would likely precipitate out as a solid

The oxidation states/charges are not balanced

Correct answer: Na and Cl should not be included

In ionic equations, include only the species that participate in reduction/oxidation. In this case, HCl and NaOH are both strong electrolytes and dissolve completely into their constituent ions: H+, Cl-, Na+, OH-. Only H+ and OH- participate in redox, forming water, so these are the only species that should be included:

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$