Chemistry Reference Tables Workbook

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About This Workbook –

Many questions on the New York State Physical Setting/CHEMISTRY Regents Exam may be answered simply by using information given on the Reference Tables. Other questions may require information from the Reference Tables to set up calculations in order to determine the answer. Knowing what information is on the Reference Tables and where to find it are very important steps towards being successful on the Regents exam.

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Chemistry Reference Tables Workbook

The Introduction – Overview, The Chart and Additional Information –

In these sections, you will find an explanation of the information given on that Table. Read each section carefully to fully understand the information given on that Table.

Set 1 – Questions and Answers –

After careful reading of the Introduction, Set 1 questions will test your understanding of that particular table. Do all questions in Set 1, and then correct your work by going to the answers for Set 1, which are at the end of the section. The explanation given will help you to understand any mistakes you may have made. If not, ask your teacher for help.

Set 2 – Questions –

The answers to these questions are in a separate answer key. Correctly answering these questions will show yourself and your teacher that you understand the subject matter for that particular Table.

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All of us at Topical Review Book Company hope that by gaining a complete understanding of the Chemistry Reference Tables will help to increase your knowledge of Chemistry and that your grades will improve.

Physical Setting/Chemistry
Reference Tables Booklet
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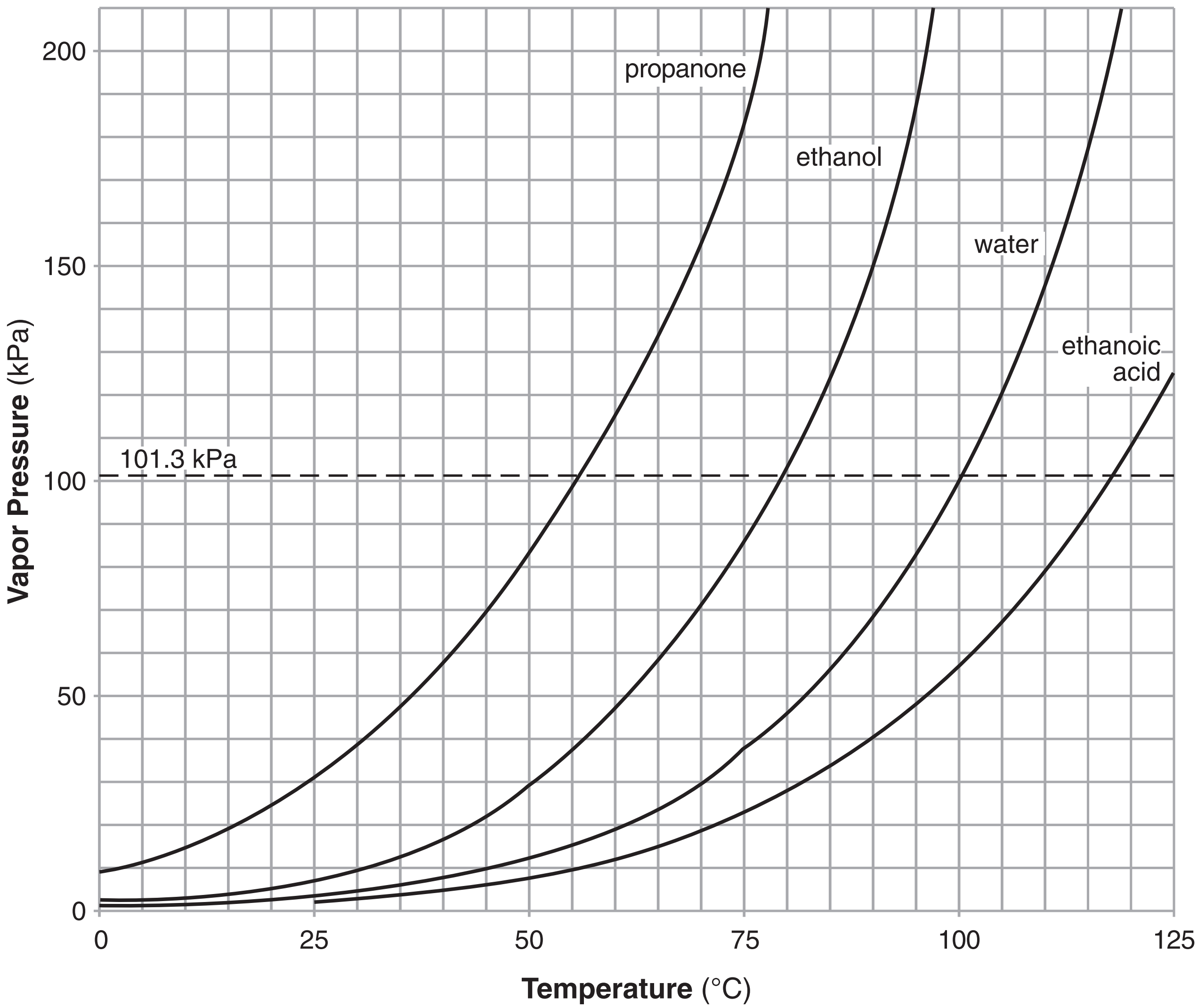
Table H — Vapor Pressure of Four Liquids



Overview:

A liquid is the form of matter that has definite volume but no definite shape. A liquid takes the shape of the container it is in. Above the surface of a liquid, there is always found the gaseous form of that liquid, called a vapor. The term vapor refers to the gas phase of a substance that is ordinarily a solid or liquid at that temperature. This vapor above the surface of a liquid exerts a characteristic pressure called vapor pressure.

The Table:

This table shows the vapor pressure, in kPa, of four liquids as a function of temperature. The graph shows that propanone has the greatest vapor pressure at any given temperature compared to the other three liquids, while ethanoic acid has the lowest vapor pressure at any given temperature compared to the other three liquids.

To determine the vapor pressure of a liquid at a specific temperature, move directly up from the given temperature until you reach the intersection point of the liquid's vapor pressure curve. Reading across to the vapor pressure axis gives the vapor pressure of that liquid at that temperature. The dotted horizontal line labeled 101.3 kPa is standard pressure (see Table A).

Temperature vs. Vapor Pressure
As the temperature increases, the vapor pressure increases. This is due to an increased amount of vapor and the greater average kinetic energy of the vapor particles. As the pressure on the surface of a liquid increases, the boiling point of the liquid increases. This is caused by the need to reach a higher vapor pressure to equal the increased pressure on the surface of the liquid.

Boiling Point and Vapor Pressure
The boiling point of a liquid is the temperature at which the vapor pressure is equal to the atmospheric pressure on the surface of the liquid. Therefore, when a liquid is boiling, the atmospheric pressure on the liquid can be read from the vapor pressure axis since they are equal to each other. When the atmospheric pressure is equal to standard pressure, the boiling point is called the normal boiling point. Reading from the graph at standard pressure (101.3 kPa), the normal boiling points of propanone, ethanol, water and ethanoic acid are 56°C, 79°C, 100°C and 117°C, respectively.

Intermolecular Attraction
A higher boiling point for a liquid indicates a greater attraction between the molecules of that liquid. The vapor pressure curves on Table H indicate that propanone has the weakest intermolecular attraction and ethanoic acid has the greatest intermolecular attraction.

Additional Information:

- The vapor pressure depends only upon the nature of the liquid and the temperature. It does not depend upon the amount of liquid.

- If a temperature-pressure point lies on one of the vapor pressure curves, the liquid is boiling, changing from the liquid to the gas phase. If the intersection point of the temperature and atmospheric pressure (read from the vapor pressure axis) of the substance is to the left of its vapor pressure curve, that substance is a liquid. If the intersection point lies to the right of the vapor pressure curve, it is a gas. For example, at 25°C and 150 kPa pressure, propanone is in the liquid phase.

Set 1 — Vapor Pressure of Four Liquids

1. Which substance has the lowest vapor pressure at 75°C?

   (1) water
   (2) ethanoic acid
   (3) propanone
   (4) ethanol

   1 _____

2. According to Reference Table H, what is the vapor pressure of propanone at 45°C?

   (1) 22 kPa (3) 70. kPa
   (2) 33 kPa (4) 98 kPa

   2 _____

3. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?

   (1) 25°C (3) 35°C
   (2) 30.°C (4) 40.°C

   3 _____

4. Jan 08 #40

5. As the temperature of a liquid increases, its vapor pressure

   (1) decreases
   (2) increases
   (3) remains the same

   5 _____

6. As the pressure on the surface of a liquid decreases, the temperature at which the liquid will boil

   (1) decreases
   (2) increases
   (3) remains the same

   6 _____

7. Using your knowledge of chemistry and the information in Reference Table H, which statement concerning propanone and water at 50°C is true?

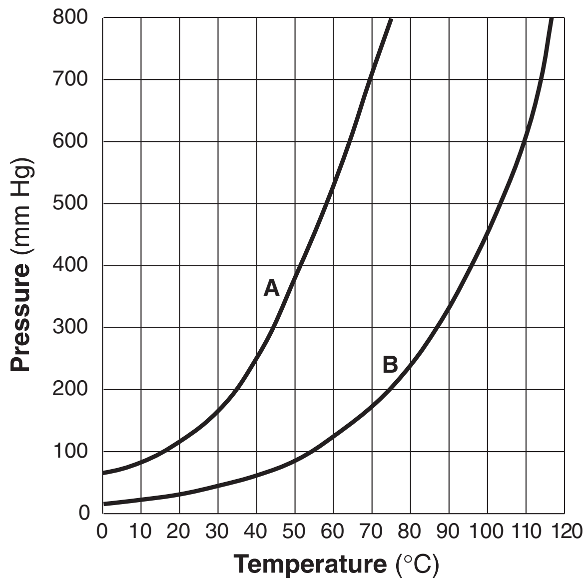
   (1) Propanone has a higher vapor pressure and stronger intermolecular forces than water.
   (2) Propanone has a higher vapor pressure and weaker intermolecular forces than water.
   (3) Propanone has a lower vapor pressure and stronger intermolecular forces than water.
   (4) Propanone has a lower vapor pressure and weaker intermolecular forces than water.

   7 _____

8. A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. Using Reference Table H, determine the boiling point of water when the atmospheric pressure is 90. kPa.

   ____

Base your answers to question 9 using your knowledge of chemistry and on the graph below, which shows the vapor pressure curves for liquids *A* and *B*. **Note:** The pressure is given in mm Hg – millimeters of mercury.



9. *a*) What is the vapor pressure of liquid *A* at 70°C? Your answer must include correct units.

____

b) At what temperature does liquid *B* have the same vapor pressure as liquid *A* at 70°C? Your answer must include correct units.

____

c) At 400 mm Hg, which liquid would reach its boiling point first? ___________________

d) Which liquid will evaporate more rapidly? Explain your answer in terms of intermolecular forces.

____

____

____

10. June 09 #18

11. Which liquid has the highest vapor pressure at 75°C?

(1) ethanoic acid (3) propanone
(2) ethanol (4) water 11 ____

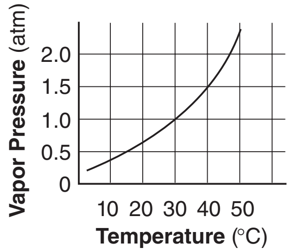
12. When the vapor pressure of water is 70 kPa the temperature of the water is

(1) 20°C (3) 60°C
(2) 40°C (4) 91°C 12 ____

13. According to Reference Table H, what is the boiling point of ethanoic acid at 80 kPa?

(1) 28°C (3) 111°C
(2) 100°C (4) 125°C 13 ____

14. The graph below shows the relationship between vapor pressure and temperature for substance **X**.



What is the normal boiling point for substance **X**?

(1) 50°C (3) 30°C
(2) 20°C (4) 40°C 14 ____

15. The table below shows the normal boiling point of four compounds.

Compound	Normal Boiling Point (°C)
HF(ℓ)	19.4
CH_3Cl(ℓ)	–24.2
CH_3F(ℓ)	–78.6
HCl(ℓ)	–83.7

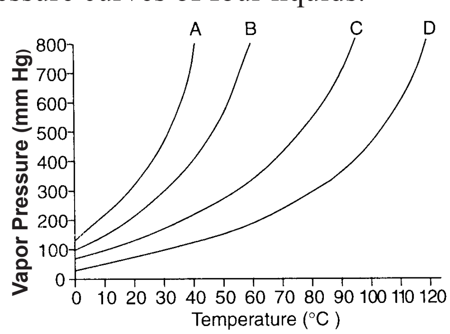
Which compound has the strongest intermolecular forces?

(1) HF(ℓ) (3) CH_3F(ℓ)
(2) CH_3Cl(ℓ) (4) HCl(ℓ) 15 ____

16. Based on Reference Table H, which subtance has the weakest intermolecular forces?

(1) ethanoic acid
(2) ethanol
(3) propanone
(4) water 16 ____

17. The graph below represents the vapor pressure curves of four liquids.



Which liquid has the highest boiling point at 600 mm Hg?

(1) *A* (3) *C*
(2) *B* (4) *D* 17 ____

18. A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using Reference Table H, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

____

19. Explain, in terms of molecular energy, why the vapor pressure of propanone increases when its temperature increases.

____

____

____

20. A sample of ethanoic acid is at 85°C. At a pressure of 50 kPa, what increase in temperature is needed to reach the boiling point of ethanoic acid? ___________

21. Based on Reference Table H, which substance has the:

strongest intermolecular forces ___________________________

weakest intermolecular forces ____________________________

22. At 70 kPa, determine the boiling point of:

propanone ________________ °C

ethanol ____________________ °C

water _____________________ °C

ethanoic acid ______________ °C

Table H – Vapor Pressure
Answers
Set 1

1. 2 On Table H, locate the 75°C line. As one moves upward the first line intersected is ethanoic acid. This would have the lowest vapor pressure at this temperature, around 23 kPa.

2. 3 On Table H, go to the 45°C temperature line. Follow this line up until it intersects the propanone vapor pressure curve. The vapor pressure is 70 kPa.

3. 3 The vapor pressure line of 48 kPa intersects the propanone vapor pressure curve at a temperature of 35°C. This intersection point represents the boiling point of propanone at this pressure.

4.

5. 2 Above the surface of a liquid, some vapor will always be found. As the temperature of the liquid increases, more of that liquid will turn to vapor. At the higher temperature, the vapor particles will possess more kinetic energy and therefore cause an increase in pressure of the vapor.

6. 1 A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. As the temperature of the liquid increases, the vapor pressure increases. If the pressure on the surface of a liquid decreases, the temperature of the liquid at which the vapor pressure will equal the atmospheric pressure will be lower. Therefore, the liquid will boil at a lower or decreased temperature.

7. 2 Open to Table H and notice that propanone has a higher vapor pressure (84 kPa) than water (12 kPa) at 50°C. The higher vapor pressure of propanone at this temperature indicates that the intermolecular forces between its molecules are weaker than that of water, allowing the molecules to escape more readily to the vapor phase.

8. Answer: 95°C *or* 96°C *or* 97°C

   Explanation: Locate the 90 kPa line on the Vapor Pressure graph. Move directly over to the right until it intersects the water vapor pressure curve. Reading down to the temperature line gives its boiling point temperature at this pressure.

9. *a*) Answer: 700 mm

Explanation: Find the 70°C value on the temperature axis of the graph and read directly up until the line intersects the vapor pressure curve of liquid *A*. Now go directly to the left to the vapor pressure axis and read the vapor pressure of liquid *A* at 70°C, which is 700 mm.

b) Answer: 114°C ± 2°C

Explanation: On the pressure axis, find the 700 mm value. Read directly to the right until this line intersects the vapor pressure curve of liquid *B*. Now read directly down to the temperature axis. The temperature value is 114°C.

c) Answer: liquid *A*

Explanation: Locate the 400 mm pressure value line. Move directly to the right from this value until it intersects the first line (liquid *A*). At this intersection point, liquid *A* is at its boiling point for this pressure.

d) Answer: liquid *A*

Explanation: At any given temperature, the vapor pressure of liquid *A* is greater than that of liquid *B*. This indicates that there are more vapor particles of liquid *A* above its surface than vapor particles of liquid *B* above its surface. One can then conclude that liquid *A* evaporates more readily than liquid *B* and therefore the intermolecular forces between molecules of *A* are less than those between molecules of *B*.

Table O — Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	α
beta particle (electron)	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	β^-
gamma radiation	${}^{0}_{0}\gamma$	γ
neutron	${}^{1}_{0}n$	n
proton	${}^{1}_{1}H$ or ${}^{1}_{1}p$	p
positron	${}^{0}_{+1}e$ or ${}^{0}_{+1}\beta$	β^+

Overview:

Radioactive elements emit particles and/or energy from their nuclei. These nuclear particles or energy have different effects on the nuclei of these elements. This radioactive decay process can be represented by nuclear equations, showing the identity of the reactants, products and the radiation released. In these equations, both charge and mass must be conserved. To balance a nuclear equation, the sum of the atomic or charge numbers on each side must be equal, and the sum of the mass numbers on each side must be equal.

The Table:

This table gives the Name, Notation (used in writing nuclear equations) and Symbol of the common types of radiation.

Going down this chart in order:

- The alpha particle (α) is a helium nucleus and is therefore positively charged.
- The beta particle (β^-) is an ordinary electron and is therefore negatively charged.
- Gamma radiation (γ), is the emission of pure energy from the nucleus - it carries no charge or mass.
- The neutron (n) is a neutral particle of unit mass found in the nucleus of atoms.
- The proton (p) is a hydrogen nucleus, a positive particle of unit mass found in the nucleus of atoms.
- The positron (β^+) is a positive electron.

As shown in the Notation section, the mass number is the number at the upper left and the atomic number is the number at the lower left. When a particle is emitted, conservation of these numbers must take place with the reactants and products. If the emission of the particle affects the atomic number, the identity of the element changes. The specifics of these changes are given on the next page.

Additional Information:

Going down the chart in order:

- During alpha decay or emission, the atomic number decreases by 2 and the mass number decreases by 4. Example: ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$

- During negative beta decay or emission, the atomic number increases by 1 and the mass number remains the same. Example: ${}^{235}_{92}U \rightarrow + {}^{235}_{93}Np + {}^{0}_{-1}e$

- During gamma emission, both the atomic number and mass number remain the same. Example: ${}^{239}_{92}U \rightarrow + {}^{239}_{92}U + {}^{0}_{0}\gamma$

- During neutron emission, the atomic number remains the same and the mass number decreases by 1. Example: ${}^{226}_{88}Ra \rightarrow {}^{225}_{88}U + {}^{1}_{0}n$

- During proton emission, both the atomic number and mass number decrease by 1. Example: ${}^{53}_{27}Co \rightarrow {}^{52}_{26}Fe + {}^{1}_{1}H$

- During positron emission, also known as positive beta emission, the atomic number decreases by 1 and the mass number remains the same. Example: ${}^{58}_{29}Cu \rightarrow {}^{58}_{28}Ni + {}^{0}_{+1}e$

- In natural transmutation, the identity of a nucleus or element changes due to a change in the number of protons (atomic number) in the nucleus. Example: ${}^{239}_{94}Pu \rightarrow {}^{235}_{92}U + {}^{4}_{2}He$

- Artificial transmutation occurs when a stable (nonradioactive) nucleus is bombarded with particles, causing it to become radioactive. Example: ${}^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$

- Nuclear fusion is the combining of lightweight nuclei to produce a heavier nucleus. This usually involves hydrogen nuclei combining to produce a helium nucleus. This is the source of solar energy. Example: ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + \text{energy}$

- Nuclear fission is the splitting of a heavier nucleus into lighter weight nuclei. U-235 and Pu-239 are the most common elements to under go fission. This is the source of the energy produced in nuclear reactors. Example: ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{54}Xe + {}^{90}_{38}Sr + 2{}^{1}_{0}n + \text{energy}$

- Nuclear reactions release large amounts of energy due to the conversion of some mass into energy according to Einstein's equation, $E = mc^2$.

- Alpha radiation, being the largest particle, has the weakest penetrating power.

- Gamma radiation, being massless and neutral, has the greatest penetrating power.

Set 1 — Symbols Used in Nuclear Chemistry

1. In the reaction $^{239}_{93}\text{Np} \rightarrow {}^{239}_{94}\text{Pu} + X$, what does X represent?

   (1) a neutron
   (2) a proton
   (3) an alpha particle
   (4) a beta particle 1 _____

2. Positrons are spontaneously emitted from the nuclei of

   (1) potassium-37
   (2) radium-226
   (3) nitrogen-16
   (4) thorium-232 2 _____

3. Given the nuclear equation:

   $$^{19}_{10}\text{Ne} \rightarrow X + {}^{19}_{9}\text{F}$$

   Which particle is represented by X?

   (1) alpha
   (2) beta
   (3) neutron
   (4) positron 3 _____

4. Which list of radioisotopes contains an alpha emitter, a beta emitter, and a positron emitter?

   (1) C-14, N-16, P-32
   (2) Cs-137, Fr-220, Tc-99
   (3) Kr-85, Ne-19, Rn-222
   (4) Pu-239, Th-232, U-238 4 _____

5. Which product of nuclear decay has mass but no charge?

   (1) alpha particles
   (2) neutrons
   (3) gamma rays
   (4) beta positrons 5 _____

6. Which type of radioactive emission has a positive charge and weak penetrating power?

   (1) alpha particle
   (2) beta particle
   (3) gamma ray
   (4) neutron 6 _____

7. Which of these types of radiation has the greatest penetrating power?

   (1) alpha (3) gamma
   (2) beta (4) positron 7 _____

8. Which reaction is an example of natural transmutation?

   (1) $^{239}_{94}\text{Pu} \rightarrow {}^{235}_{92}\text{U} + {}^{4}_{2}\text{He}$
   (2) $^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \rightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$
   (3) $^{238}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{239}_{94}\text{Pu} + 2\,{}^{0}_{-1}\text{e}$
   (4) $^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \rightarrow {}^{147}_{56}\text{Ba} + {}^{90}_{38}\text{Sr} + 3\,{}^{1}_{0}\text{n}$

   8 _____

9. The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called

   (1) natural transmutation
   (2) artificial transmutation
   (3) natural decay
   (4) radioactive decay   9 _____

10. One benefit of nuclear fission reactions is

   (1) nuclear reactor meltdowns
   (2) storage of waste materials
   (3) biological exposure
   (4) production of energy   10 ____

11. In a nuclear fusion reaction, the mass of the products is

   (1) less than the mass of the reactants because some of the mass has been converted to energy
   (2) less than the mass of the reactants because some of the energy has been converted to mass
   (3) more than the mass of the reactants because some of the mass has been converted to energy
   (4) more than the mass of the reactants because some of the energy has been converted to mass   11 ____

---

12. Given the nuclear equation: ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3{}^{1}_{0}n + \text{energy}$

   a) State the type of nuclear reaction represented by the equation. ___________________________

   b) The sum of the masses of the products is slightly less than the sum of the masses of the reactants. Explain this loss of mass.

   ____

   ____

   c) This process releases greater energy than an ordinary chemical reaction does. Name another type of nuclear reaction that releases greater energy than an ordinary chemical reaction.

   ____

13. Using Reference Table N, complete the equation below for the nuclear decay of ${}^{226}_{88}Ra$. Include both atomic number and mass number for each particle.

   ${}^{226}_{88}Ra \rightarrow$ _____________ + _____________

Set 2 — Symbols Used in Nuclear Chemistry

14. Given the nuclear equation:

$$^{14}_{7}\text{N} + X \rightarrow {}^{16}_{8}\text{O} + {}^{2}_{1}\text{H}$$

What is particle *X*?

(1) an alpha particle
(2) a beta particle
(3) a deuteron
(4) a triton 14 ____

15. In the reaction $^{9}_{4}\text{Be} + X \rightarrow {}^{6}_{3}\text{Li} + {}^{4}_{2}\text{He}$, the *X* represents

(1) $^{0}_{+1}\text{e}$
(2) $^{1}_{1}\text{H}$
(3) $^{0}_{-1}\text{e}$
(4) $^{1}_{0}\text{n}$ 15 ____

16. Given the nuclear reaction:

$$^{32}_{16}\text{S} + {}^{1}_{0}\text{n} \rightarrow {}^{1}_{1}\text{H} + X$$

What does *X* represent in this reaction?

(1) $^{31}_{15}\text{P}$
(2) $^{32}_{15}\text{P}$
(3) $^{31}_{16}\text{S}$
(4) $^{32}_{16}\text{S}$ 16 ____

17. Given the nuclear equation:

$$^{253}_{99}\text{Es} + X \rightarrow {}^{1}_{0}\text{n} + {}^{256}_{101}\text{Md}$$

Which particle is represented by X?

(1) $^{4}_{2}\text{He}$
(2) $^{0}_{-1}\text{e}$
(3) $^{1}_{0}\text{n}$
(4) $^{0}_{+1}\text{e}$ 17 ____

18. Given the equation: $^{239}_{93}\text{Np} \rightarrow {}^{239}_{94}\text{Pu} + X$

When the equation is balanced correctly, which particle is represented by *X*?

(1) $^{0}_{-1}\text{e}$
(2) $^{1}_{1}\text{H}$
(3) $^{2}_{1}\text{H}$
(4) $^{1}_{0}\text{n}$ 18 ____

19. Which of these particles has the greatest mass?

(1) alpha (3) neutron
(2) beta (4) positron 19 ____

20. Types of nuclear reactions include fission, fusion, and

(1) single replacement
(2) neutralization
(3) oxidation-reduction
(4) transmutation 20 ____

21. Nuclear fusion differs from nuclear fission because nuclear fusion reactions

(1) form heavier isotopes from lighter isotopes
(2) form lighter isotopes from heavier isotopes
(3) convert mass to energy
(4) convert energy to mass 21 ____

22. Which equation is an example of artificial transmutation?

(1) ${}^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$
(2) $U + 3\ F_2 \rightarrow UF_6$
(3) $Mg(OH)_2 + 2\ HCl \rightarrow 2\ H_2O + MgCl_2$
(4) $Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$

22 ____

23. Which equation represents a fusion reaction?

(1) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{4}_{2}He$
(2) ${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + {}^{14}_{7}N$
(3) ${}^{238}_{92}U + {}^{4}_{2}He \rightarrow {}^{241}_{94}Pu + {}^{1}_{0}n$
(4) ${}^{1}_{0}n + {}^{27}_{13}Al \rightarrow {}^{24}_{11}Na + {}^{4}_{2}He$

23 ____

24. Which list of nuclear emissions is arranged in order from the least penetrating power to the greatest penetrating power?

(1) alpha particle, beta particle, gamma ray
(2) alpha particle, gamma ray, beta particle
(3) gamma ray, beta particle, alpha particle
(4) beta particle, alpha particle, gamma ray

24____

25. Complete the equation below for the radioactive decay of ${}^{137}_{55}Cs$. Include both atomic number and mass number for each particle.

$${}^{137}_{55}Cs \rightarrow \_\_\_\_\_\_\_ + \_\_\_\_\_\_\_$$

26. Complete the nuclear equation below for the decay of K-42. Your response must include the atomic number, the mass number, and the symbol of the missing particle.

$${}^{42}_{19}K \rightarrow {}^{0}_{-1}e + \_\_\_\_\_\_\_\_\_$$

27. Complete the nuclear equation below for the decay of C-14. Your response must include the atomic number, the mass number, and the symbol of the missing particle.

$${}^{14}_{6}C \rightarrow {}^{0}_{-1}e + \_\_\_\_\_\_\_\_\_$$

Table O – Symbols Used in Nuclear Chemistry
Answers
Set 1

1. 4 In a nuclear reaction, the sum of the atomic numbers on each side must be equal and the sum of the mass numbers on each side must be equal. Particle *X* therefore must have a charge number of –1 and a mass number of 0. From Table O, this must be a beta particle. Np, element 93, is a man-made radioactive element that changes to Pu, element 94, by releasing a beta particle.

2. 1 Table O shows that a positron, also known as a positive beta particle, has the symbol β^+. Open to Table N and locate K-37. Under Decay Mode, it shows that this element undergoes positron emission. During positron emission, the atomic number decreases by 1 and the mass number remains the same

3. 4 To balance the nuclear equation, particle *X* must have a +1 charge and zero mass. Using the notation column in Table O, a positron has a +1 charge and 0 mass. During positron emission, the atomic number decreases by 1 and the mass number remains the same.

4. 3 Table O gives the particles and their notations referred to in this question. Using Table N, find the radioisotopes given in choice 3. The Decay Mode shows that choice 3 contains an alpha emitter, a beta emitter and a positron emitter.

5. 2 Looking at Table O, the neutron has the symbol ${}^{1}_{0}n$, indicating it has an atomic mass of 1 and carries no charge.

6. 1 The first particle shown in Table O is the alpha particle. This particle is a helium nucleus, consisting of 2 protons and 2 neutrons. This makes this particle positive in charge. The alpha particle is the largest particle that is emitted in radioactive decay. Being the largest particle, it would have the weakest penetrating power, giving up more energy with each particle it collides with.

7. 3 In the notation column of Table O, it shows that gamma radiation has no charge or mass. A massless, neutral particle can easily pass through matter without interacting with it. This makes the gamma radiation the most penetrating of the given choices.

8. 1 In natural radioactivity, also called natural transmutation, a radioactive element will undergo a spontaneous decay process involving the nucleus. An example of this decay is radioactive Pu-239 changing to U-235 by alpha emission. Choices 2 and 3 show artificial transmutation (see explanation for answer no. 9). Choice 4 shows the fission of a Pu-239 nucleus.

9. 2 In artificial transmutation, the nucleus of a non-radioactive element is bombarded with high energy particles, such as alpha particles, protons or neutrons. The end product of artificial transmutation is the formation of new radioactive elements.

10. 4 When nuclear fission occurs, a very large amount of energy is released. Under controlled conditions, this energy can safely be harnessed, changed to electrical energy and distributed to benefit mankind.

11. 1 In any nuclear reaction, the mass of the products is less than the mass of the reactants. This difference in mass is converted into a large amount of energy according to Einstein's equation, $E = mc^2$.

12. *a*) Answer: nuclear fission

Explanation: A neutron is captured by the nucleus of a uranium atom. This causes uranium to undergo nuclear fission, producing two lighter elements, while giving off subatomic particles and energy.

b) Answer: Mass has been converted into energy.

Explanation: In any nuclear reaction, the mass of the products is less than the mass of the reactants. This difference in mass is converted into a large amount of energy according to Einstein's equation, $E = mc^2$.

c) Answer: Nuclear fusion *or* natural transmutation *or* radioactive decay *or* nuclear decay

Explanation: In a nuclear fusion reaction, lighter nuclei combine or unite to form a heavier nucleus. As in any nuclear reaction, the mass of the products is less than the mass of the reactants. This difference in mass has been converted into energy.

13. Answer: ${}^{226}_{88}\text{Ra} \rightarrow {}^{4}_{2}\text{He} + {}^{222}_{86}\text{Rn}$ *or* ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\alpha$

Explanation: Locate Ra-226 in Table N. It shows that this element undergoes alpha emission. Table O shows the notation of an alpha particle. The above equations show that atomic number and mass number are conserved.

Table T — Titration

$M_AV_A = M_BV_B$	M_A = molarity of H^+	M_B = molarity of OH^-
	V_A = volume of acid	V_B = volume of base

Overview:

Titration is a process used to determine the concentration (molarity) of an acid or base by slowly combining it with a base or acid, respectively, of known concentration, called a standard.

Example:

What volume of 0.250 M HCl(aq) must completely react to neutralize 50.0 milliliters of 0.100 M NaOH(aq)?

Solution: M_A = 0.250 M HCl(aq), V_A = unknown, M_B = 50.0M NaOH(aq) and V_B = 50.0 mL.

Substitution: (0.250 M)(V_A) = (0.100 M)(50.0 mL)

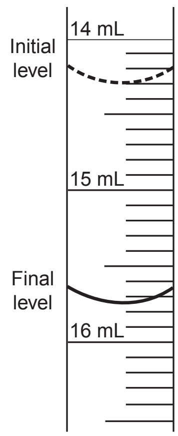
Answer: V_A = 20.0 mL

Additional Information:

- An indicator can be used to determine the end point in an acid-base titration. At the end point, the resulting solution is not necessarily neutral (pH = 7). It depends on the strength of the acid and base.
- The net ionic equation for a neutralization reaction is $H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$.
- If the number of H^+ in the acid formula and the number of OH^- in the base formula are the same, the calculated concentration of the acid or base is the correct concentration.
- When calculating the concentration of an acid, if the acid has 2 H^+ and the base has 1 OH^-, divide the calculated concentration by 2 to obtain the correct concentration of the acid, See Set 1, question 4.
- When calculating the concentration of a base, if the base has 2 OH^- and the acid has 1 H^+, divide the calculated concentration by 2 to obtain the correct concentration of the base.

Set 1 — Titration

1. The diagram represents a section of a buret containing acid used in an acid-base titration. What is the total volume of acid that was used?



(1) 1.10 mL
(2) 1.30 mL
(3) 1.40 mL
(4) 1.45 mL

1 _____

2. If 5.0 milliliters of a 0.20 M HCl solution is required to neutralize exactly 10. milliliters of NaOH, what is the concentration of the base?

(1) 0.10 M (3) 0.30 M
(2) 0.20 M (4) 0.40 M 2 _____

3. What volume of 0.500 M HNO_3(aq) must completely react to neutralize 100.0 milliliters of 0.100 M KOH(aq)?

(1) 10.0 mL (3) 50.0 mL
(2) 20.0 mL (4) 500. mL 3 _____

4. Information related to a titration experiment is given in the balanced equation and table below.

Titration Experiment Results

volume of H_2SO_4(aq) used	12.0 mL
concentration of H_2SO_4(aq)	?
volume of KOH(aq) used	36.0 mL
concentration of KOH(aq)	0.16 M

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(\ell)$$

Based on the equation and the titration results, what is the concentration of the H_2SO_4(aq)?

(1) 0.12 M (3) 0.24 M
(2) 0.16 M (4) 0.96 M 4 _____

5. Samples of acid rain are brought to a laboratory for analysis. Several titrations are performed and it is determined that a 20.0-milliliter sample of acid rain is neutralized with 6.50 milliliters of 0.010 M NaOH. What is the molarity of the H^+ ions in the acid rain?

Base your answers to question 6 using the information below and your knowledge of chemistry.

A student titrates 60.0 mL of HNO_3(aq) with 0.30 M NaOH(aq). Phenolphthalein is used as the indicator. After adding 42.2 mL of NaOH(aq), a color change remains for 25 seconds, and the student stops the titration.

6. *a*) What color change does phenolphthalein undergo during this titration? ____________________

b) Show a correct numerical setup for calculating the molarity of the HNO_3(aq).

7. A student recorded the following buret readings during a titration of a base with an acid:

	Standard 0.100 M HCl	Unknown KOH
Initial reading	9.08 mL	0.55 mL
Final reading	19.09 mL	5.56 mL

a) Calculate the molarity of the KOH. Show all work.

b) Record your answer to the correct number of significant figures. ___________________________

Base your answers to question 8 using the information below and your knowledge of chemistry.

In a titration, 3.00 M NaOH(aq) was added to an Erlenmeyer flask containing 25.00 milliliters of HCl(aq) and three drops of phenolphthalein until one drop of the NaOH(aq) turned the solution a light-pink color. The following data were collected by a student performing this titration:

Initial NaOH(aq) buret reading: 14.45 milliliters
Final NaOH(aq) buret reading: 32.66 milliliters

8. *a*) What is the total volume of NaOH(aq) that was used in this titration? _______________________

b) Show a correct numerical setup for calculating the molarity of the HCl(aq).

c) Based on the data given, what is the correct number of significant figures that should be shown in the molarity of the HCl(aq)? _____________________

Set 2 — Titration

9. Which process uses a volume of solution of known concentration to determine the concentration of another solution?

   (1) distillation
   (2) substitution
   (3) transmutation
   (4) titration 9 _____

10. If 5.0 milliliters of a 0.20 M HCl solution is required to neutralize exactly 10. milliliters of NaOH, what is the concentration of the base?

    (1) 0.10 M (3) 0.30 M
    (2) 0.20 M (4) 0.40 M 10 ____

11. How many milliliters of 0.20 M KOH are needed to completely neutralize 90.0 milliliters of 0.10 M HCl?

    (1) 25 mL (3) 90. mL
    (2) 45 mL (4) 180 mL 11 ____

12. When 50. milliliters of an HNO_3 solution is exactly neutralized by 150 milliliters of a 0.50 M solution of KOH, what is the concentration of HNO_3?

    (1) 1.0 M (3) 3.0 M
    (2) 1.5 M (4) 0.5 M 12 ____

Base your answers to question 13 using the information below and your knowledge of chemistry.

Using burets, a student titrated a sodium hydroxide solution of unknown concentration with 0.10 M HCL.

Titration Data

Solution	HCl(aq)	NaOH(aq)
Initial Buret Reading (mL)	15.50	5.00
Final Buret Reading (mL)	25.00	8.80

13. *a*) Determine both the total volume of HCl(aq) and the total volume of NaOH(aq) used in the titration.

    HCl(aq) = _____________ mL

    Na(OH)(aq) = __________ mL

    b) Show a correct numerical setup for calculating the molarity of the sodium hydroxide solution.

    c) Solve for the molarity of the sodium hydroxide solution.

Base your answers to question 14 using the information below and your knowledge of chemistry.

In a laboratory activity, 40.0 mL with a concentration of 0.500 M of NaOH(s) must completely react to neutralize 400. milliliters of HNO_3(aq).

14. *a*) Identify the negative ion produced when the NaOH(s) is dissolved in distilled water. _________

b) In the space below, calculate the molarity of the HNO_3(aq). Your response must include both a correct numerical setup and the calculated result.

c) Complete the equation representing this titration reaction by writing the formulas of the products.

NaOH(aq) + HNO_3(aq) → _______________ + _______________

Base your answers to question 15 on the information below.

In preparing to titrate an acid with a base, a student puts on goggles and an apron. The student uses burets to dispense and measure the acid and the base in the titration. In each of two trials, a 0.500 M NaOH(aq) solution is added to a flask containing a volume of HCl(aq) solution of unknown concentration. Phenolphthalein is the indicator used in the titration. The calculated volumes used for the two trials are recorded in the table below.

Volumes of Base and Acid Used in Titration Trials

		Trial 1	Trial 2
Solution (aq)	**Molarity** (M)	**Volume Used** (mL)	**Volume Used** (mL)
NaOH	0.500	17.03	16.87
HCl	?	10.22	10.12

15. *a*) Write a chemical name for the acid used in the titration.

____

b) Using the volumes from trial 1, determine the molarity of the HCl(aq) solution.

c) Based on the information given in the table, how many significant figures should be shown in the calculated molarity of the HCl(aq) solution used in trial 2? _________________

Table T – Titration
Answers
Set 1

1. 4 Subtracting the final level from the initial level will give the total volume of acid used in the titration.

   Readings: final level = 15.75 mL, initial level = 14.30 mL. The difference of these readings is 1.45 mL.

2. 1 In an acid-base titration procedure, a solution of known concentration (the standard) is used to determine the unknown concentration of an acid or base by reaching neutralization.

   The given acid is HCl and the given base is NaOH.

   Equation: $M_A V_A = M_B V_B$

   Given values: $M_A = 0.20$ M, $V_A = 5.0$ mL, $V_B = 10.$ mL, M_B is the unknown

   Substituting: (0.20 M)(5.0 mL) = (M_B)(10. mL)

   Solving: $M_B = \frac{(5.0 \text{ mL})(0.20 \text{ M})}{10. \text{ mL}} = 0.10$ M.

3. 2 The acid-base titration method is used to determine the unknown concentration (molar concentration) of an acid or base. The given acid is HNO_3 and the given base is KOH.

   Given values: $M_A = 0.500$ M, $M_B = 0.100$ M, V_B =100.0mL, V_A is the unknown

   Equation: $M_A V_A = M_B V_B$.

   Substituting: (0.500 M)(V_A) = (0.100 M)(100.0 mL)

   Solving: $V_A = \frac{(0.100 \text{ M})(100.0 \text{ mL})}{0.500 \text{ M}} = 20.0$ mL

4. 3 The acid-base titration method is used to determine the unknown concentration (molar concentration) of an acid or base. The given acid is H_2SO_4 and the given base is KOH.

   Given values: $V_A = 12.0$ mL, $M_B = 0.16$ M, $V_B = 36.0$ mL, M_A is the unknown

   Equation: $M_A V_A = M_B V_B$.

   Substituting: (M_A) (12.0 mL) = (0.16 M)(36.0 mL)

   Solving: $M_A = 0.48$ M Dividing by 2 gives: 0.48 M/2 = 0.24 M

   Note: the acid is a diprotic acid (two moles of H^+ per mole of acid) and the base is a monohydroxy base (one mole of OH^- per mole of base). Therefore, it will require a solution of acid only one-half the calculated concentration for this titration:

   $$\frac{0.48}{2} = 0.24 \text{ M}$$

   In a titration, the neutralization equation is: $H^+ + OH^- \rightarrow HOH$ (1:1 ratio for H^+ to OH^-).

5. Answer: 0.0033 M *or* 3.25×10^{-3} M *or* 3.3×10^{-3} M

Explanation: The acid-base titration method is used to determine the unknown concentration (molar concentration) of an acid or base.

Given values: V_A = 20.0 mL, M_B = 0.010 M, and V_B = 6.50 mL M_A = is the unknown for molarity of H^+ ions

Equation: $M_A V_A = M_B V_B$

Substituting: (M_A)(20.0 mL) = (0.010 M)(6.50 mL)

Solving: M_A of H^+ ions = 0.0033 M

6. *a*) Answer: colorless to pink *or* no color to red

Explanation: Phenolphthalein is colorless in the HNO_3(aq) solution. When NaOH(aq), a base (see Table L), is added to the HNO_3(aq), an acid (see Table K), the pH of the solution increases. When the pH of the solution becomes 8.2, the phenolphthalein will change to a pink color (see Table M).

b) Answer: $M_A = \dfrac{(0.30\text{ M})(42.2\text{ mL})}{60.0\text{ mL}}$ *or* (×)(60) = (.3)(42.2)

Explanation: Open to Table K and L. Here it identifies HNO_3 as nitric acid and NaOH as sodium hydroxide, a base.

Given values: V_A = 60.0 mL of HNO_3, M_B = 0.30 M, V_B = 42.2 mL, M_A is the unknown molarity of HNO_3(aq)

Equation: $M_A V_A = M_B V_B$

Substituting: (M_A)(60.0 mL) = (0.30 M)(42.2 mL)

Correct numerical setup: $M_A = \dfrac{(0.30\text{ M})(42.2\text{ mL})}{60.0\text{ mL}}$

7. *a*) Answer: $M_B = \frac{(0.100 \text{ M})(10.01 \text{ mL})}{5.01 \text{ mL}}$ *or* $(0.100 \text{ M})(10.01 \text{ mL}) = (M_B)(5.01 \text{ mL})$

Explanation: As shown in the chart, the acid is HCl and the base is KOH.

Given values: V_A = 10.01 mL (19.09 mL – 9.08 mL), V_B = 5.01 mL (5.56 mL – 0.55 mL), M_A = 0.100 M, M_B = molarity of KOH is the known

Equation: $M_A V_A = M_B V_B$

Substituting: $(0.100 \text{ M})(10.01 \text{ mL}) = (M_B)(5.01 \text{ mL})$

Solving: $M_B = \frac{(0.100 \text{ M})(10.01 \text{ mL})}{5.01 \text{ mL}}$

b) Answer: M_B = 0.200 to three significant figures.

Explanation: When multiplying and dividing, the answer must be expressed to the same number of significant figures as that in the least accurate measurement (that with the least number of significant figures). In this case, the number is 3, found in both 0.100 M and 5.01 mL. The number 10.01 mL contains 4 significant figures.

8. *a*) Answer: 18.21 mL

Explanation: Subtracting the final buret reading from the initial buret reading gives the volume of base used, 32.66 mL – 14.45 mL = 18.21 mL.

b) Numerical setup: $M_A = \frac{(3.00 \text{ M})(18.21 \text{ mL})}{25.00 \text{ mL}}$ *or* $M_A(25) = (3)(18.21)$

Explanation: As shown in Table K and L, NaOH(aq) is a base and HCl(aq) is an acid. The variables given are: M_B = 3.00 M, V_A = 25.00 mL, V_B = 18.21 mL, M_A = is the unknown for HCl(aq).

Substituting into the titration equation gives you the setup shown above.

c) Answer: 3 *or* three

Explanation: Refer to the rule given in the explanation for question 7*b*. In this case, 3.00 M has 3 significant figures and 18.21 mL and 25.00 mL both have 4 significant figures. The least number of significant figures in these measurements is 3. Therefore, the answer must be rounded to 3 significant figures.