AP exam math review

Most common math concepts:

- Exponential decay: radioactive elements, A=Ao(1/2)^n where n is the number of half lives
- Isotopes: atomic number (protons) and atomic mass (p+n)
- Exponential growth: populations, rule of 70, 70/% = doubling time
- pH: log10 of [H+], 10x per pH value
- Trophic pyramids: 10% rule
- Energy vs. power: work is joules, joules/time = power, kW, kWh
- Photosynthesis: follow carbon: CO2 + H2O-> sugars (carbohydrates)
- Ocean acidification: CO2 + H2O <-> H2CO3<->H+ + HCO3-
- Ozone depletion: track Chlorine
- Respiration and combustion
- Aerobic vs. anaerobic respiration
- Efficiency: work out/work in (always less than 100%)

□□ 1. Exponential Decay (Radioactive Elements)

A scientist begins with 100 grams of a radioactive isotope with a half-life of 5 years.

How much of the substance remains after 15 years?

⚛ 2. Isotopes (Atomic Number and Mass)

Carbon-12 and Carbon-14 are both isotopes of carbon.

What do they have in common, and how are they different in terms of protons and neutrons?

□□ 3. Exponential Growth (Rule of 70)

A country has a population growth rate of 2% per year.

Use the Rule of 70 to estimate how many years it will take for the population to double.

□□ 4. pH (Log Scale)

Lemon juice has a pH of 2. Tomato juice has a pH of 4.

How many times more acidic is lemon juice compared to tomato juice?

□□ 5. Trophic Pyramids (10% Rule)

If a plant produces 10,000 Joules of energy,

How much energy is available to a secondary consumer?

⚡ 6. Energy vs. Power

A microwave uses 1.2 kilowatts (kW) of power. If it runs for 30 minutes,

How much energy (in kilowatt-hours) does it use?

□□ 7. Photosynthesis (Tracking Carbon)

In the process of photosynthesis, carbon dioxide and water form glucose and oxygen.

Which molecule provides the carbon atoms found in glucose?

□□ 8. Ocean Acidification

Explain what happens to the pH of ocean water as more CO_2 is absorbed from the atmosphere.

Use the equation: $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

☁ 9. Ozone Depletion (Tracking Chlorine)

One chlorine atom from CFCs can destroy thousands of ozone molecules.

How does chlorine act as a catalyst in ozone depletion?

□□ 10. Respiration and Combustion

Compare **respiration** and **combustion** in terms of energy release and byproducts.

□□ 11. Aerobic vs. Anaerobic Respiration

During intense exercise, muscles may switch to anaerobic respiration.

What are the differences in energy output and waste products between aerobic and anaerobic respiration?

⚙ 12. Efficiency (Work Out / Work In)

A motor receives 500 J of electrical energy and does 350 J of useful work.

What is the efficiency of the motor as a percentage?

Answer Key

1. **12.5 grams** (100 → 50 → 25 → 12.5 over 3 half-lives)
2. **Both have 6 protons (same atomic number); Carbon-12 has 6 neutrons, Carbon-14 has 8 neutrons (different atomic mass).**
3. **35 years** (70 ÷ 2 = 35)
4. **100 times more acidic** (10^2)
5. **100 Joules** (10% of 1000, which is 10% of 10,000)
6. **0.6 kWh** (1.2 kW × 0.5 hr = 0.6 kWh)
7. **CO_2 (carbon dioxide)**
8. **Ocean pH decreases (becomes more acidic) as H^+ concentration increases due to carbonic acid dissociation.**
9. **Chlorine breaks ozone into O_2 and ClO, then regenerates to destroy more ozone (acts repeatedly).**
10. **Both release energy and CO_2; respiration is controlled, slow, uses glucose and O_2; combustion is fast, uses fuel and O_2.**
11. **Aerobic: more ATP, produces CO_2 + H_2O; Anaerobic: less ATP, produces lactic acid or ethanol.**
12. **70% efficiency** (350 ÷ 500 × 100 = 70%)

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List of Chemical Formulas

Here are the important chemical APES formulas:

Common Name	Chemical Equation
Respiration	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
Combustion	Hydrocarbons (C_xH_y) + $O_2 \rightarrow CO_2 + H_2O$
Photosynthesis	$6CO_2 + 6H_2O$ + sunlight $\rightarrow C_6H_{12}O_6 + 6O_2$
Ocean acidification	$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
Photochemical smog formation	NO_x + VOCs + heat + sunlight $\rightarrow$ smog
Stratospheric ozone depletion	$O_3 + Cl \rightarrow O_2 + ClO$

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Notes:
Follow carbon in each equation
Sugar holds energy in bonds, released in respiration
Hydrocarbons "burn" to produce CO2 and water
Photosynthesis stores sunlight as bonds in sugar (reverse of respiration)
H+ lowers the pH of ocean water, impacts corals and other creatures
NOx and SOx are primary pollutants, sunlight (energy) creates secondary pollutants (e.g. acid rain)
Cl in CFC breaks O3 into O2 (transparent to UV radiation)

List of Mathematical Routines

Here are the important mathematical routines:

Common Name	Mathematical Formula
Population density	$\frac{Population}{Area}$
Rule of 70	$\frac{70}{Percent\ growth\ rate}$
Population growth rate as a percent	$\frac{Births - Deaths}{Number\ of\ people} \times 100$
Rate of change	$\frac{Final - Initial}{Final\ time - Initial\ time}$
Percent change	$\frac{Final - Initial}{Initial} \times 100$
Net Primary Productivity (NPP)	*Gross primary productivity (GPP) - Respiration*

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Note:

Rule of 70 is for doubling time, could also be used in reverse to have decay rate
Rule of 70 will usually use variations of 7: 7, 14, 28, 35 as percent growth (or decay)

Gross Primary Productivity (GPP)	*GPP = Rate of photosynthesis by plants* *GPP can also be expressed as:* *GPP = Total solar energy captured by plants – Energy lost due to respiration by plants*
Fuel efficiency	$\frac{Distance\ traveled}{Unit\ of\ fuel\ consumed}$
The 10% Rule	*The 10% rule states that roughly only 10% of energy transfers between trophic levels in a food chain, with the rest being lost as heat.*
Dimensional Analysis	$Quantity\ 1 \times \frac{Conversion\ factor}{Quantity\ 2} = Result$
Half-Life	$t_{½} = \frac{ln\,(2)}{\lambda}$
LD_{50}	$LD_{50} = \frac{Dose}{Weight}$

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Power and energy:
Energy: the ability to do work
Joules or calories, 1000 calories is a kcal or one food Calorie
Could be potential energy like a student a certain height above the ground: PE = mgh
Could also be potential energy in a chemical bond, like in sugar or gasoline
Could be kinetic energy of motion, like a running student or a fast molecule (ionosphere?)

Power: how fast the work is done
Units are: horsepower, Watts or kW (kiloWatts)
One Watt = 1 joule every second: j/s
KiloWatt: 1000j/s
Horsepower: 746 Watts

Electrical energy use:
A hot water heater might use energy at the rate 1200W or 1.2kW or 1200 joules every second (power)
Multiply power by time to get energy: 1.2 kW x 1 hour = 1.2kWh
Electricity is charged by the kWh, usually about $0.07 per kWh in the mainland

Examples:
A 4.5 kW residential hot water heater is used 4 hours per day where electricity costs $0.10/kWh
4.5 kW x 4 hours = 18 kWh, 18 x 0.10 = $1.80

Electrical use in a certain country is predicted to increase by 3.5%, when will this electrical use double?
70/3.5 = 20 years

Designing an experiment:
A teacher wishes to determine if giving students caffeinated drinks during class increases engagement in class.
Hypothesis: Caffeine increases engagement and retention of material
Control group: students with drinks without caffeine (caffeine free tea) n.b. this separates drinks as a variable
Independent variable: Caffeinated drinks (non, one, more than one)
Dependent variable: engagement in class, based on retention of material
Experiment: pre-class test, post-class test to measure retention, various drinks for students
Data: more caffeine increases retention
What is wrong with this experiment?
1. different students learn differently
2. some have higher threshold for caffeine
3. some have negative impact of caffeine
4. some may have already had caffeine
5. testing of retention is much more complex

Population problems:
Know the phases of demographic transition, and population pyramids
Rule of 70 and immigration-emigration formulas (above)
r specific growth (J curves)
K specific growth (logistic curve with carrying capacity)

Layers: know these
Atmosphere
Soil
Earth
Oceans
Lakes
Rivers (riparian)

FRQ Reminders in AP Environmental Science

1. Always write in complete sentences.
2. Don’t write more than the question asks for.
3. If the FRQ asks for two examples, only the first two examples that you write are graded.
4. Introductory sentences or re-stating the question is not necessary. No points removed, but it can take precious time.
5. Label each section: a. b. ci……. DO NOT write one giant paragraph and write on the lines.
6. You can answer out of order—just make sure to label.
7. If you write more, the graders will read them to check for contradictions, but you will not earn points. Contradictions will take away points.

FRQ Task Verbs

Identify, Provide or List: Simple answer with a complete sentence.

Describe: Needs additional information beyond a simple answer. 1-2 complex sentences.

Make a Claim: Make an assertion based on evidence or knowledge. Make sure you add “Because” or “Which leads to” in your answer to get full points

Justify: Provide evidence to support, qualify, or defend a claim and/or provide reasoning to explain HOW that evidence supports the claim.

Calculate: A math problem to solve. Show set-up and answer WITH UNITS. (Does not need complete sentence)

Explain: HOW or WHY something occurs.

- Use evidence and/or reasoning.
- Sometimes, it is a process requiring steps in order.
- Use “because” for “why” questions.
- It often requires 3 parts: This happens, which leads to, which results in.

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