Chemistry 30: Review Booklet

The diploma examination consists of 44 Multiple Choice worth 73% of the exam, and 16 Numerical Response questions worth 17% of the exam. These questions may stand alone or be linked to one another. In linked questions, the answer from one question is used to complete the next question. If you answer the first question incorrectly but use that answer correctly to answer the second question, you will still receive full marks for the second question

The examination is 2.5 hours in length. Budget about 2 minutes 20 seconds per question, and this should leave about 10 minutes at the end to revise and double check your work before handing it in.

Breakdown of the examination:

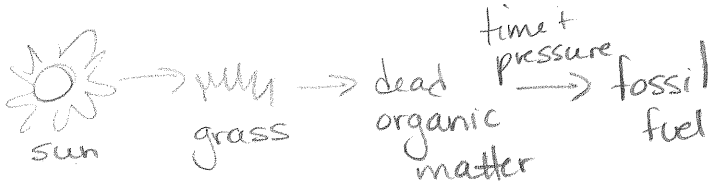
Unit A = Thermochemistry = 20–22%
Unit B = Electrochemistry (Redox) = 32–34%
Unit C = Organic Chemistry = 12–16%
Unit D = Equilibrium and Acid-Base Chemistry = 30–32%

Here are some practice questions representative of a diploma examination.

Use the following information to answer the next question.

Processes

1	Combustion
2	Photosynthesis
3	Bacterial decay
4	Energy from the sun



Numerical Response

1. From the formation of methane to its eventual use as automobile fuel, the order of the processes listed above is 4 , 2 , 3 , and 1 .

(Record your **four-digit** answer in the numerical response section of your answer sheet.)

1. A student mixes 41.8 g of ethanol at 15.8°C with 50.7 g of water at 49.2°C. If the resulting temperature of the solution is 38.4°C, what is the specific heat capacity of the ethanol?

A. 2.43 J/(g • °C)
B. 3.45 J/(g • °C)
C. 4.19 J/(g • °C)
D. 6.51 J/(g • °C)

$Q_{(water)} = mc\Delta t$
$= (50.7g)(4.19J/g\cdot°C)(38.4-49.2°C)$
$= -2294.2764J$

$Q_{(ethanol)} = mc\Delta t$
$+2294.2764J = (41.8g)(c)(38.4-15.8°C)$
$c = 2.4286 J/g\cdot°C$

2. In a chemistry experiment, 12 g of $(NH_4)_2SO_4(s)$ was dissolved in 120 mL of water in a simple calorimeter. A temperature change from 20.2°C to 17.8°C was observed. The experimental molar enthalpy of solution for ammonium sulphate was

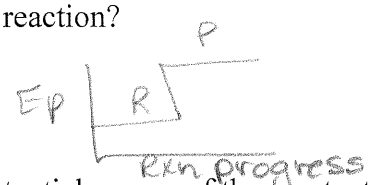
$n\Delta_r H_m = -mc\Delta t$

$\left(12g \times \frac{mol}{132.17g}\right)(\Delta_r H_m) = -(0.120kg)(4.19\frac{J}{g \cdot °C})(-2.4°C)$

$\Delta_r H_m = +13.29\ kJ/mol$

A. +13 kJ/mol
B. +1.2 kJ/mol
C. –1.2 kJ/mol
D. –13 kJ/mol

3. Which of the following statements is **true** for an endothermic reaction?



A. ΔE_p for the reaction is negative. $\Delta H = \Delta E$
B. Energy is a product in the chemical equation.
C. The temperature of the surroundings increases.
D. The potential energy of the products is greater than the potential energy of the reactants.

Use the following information to answer the next question.

Prior to the development of the Hall-Héroult process for producing aluminum, pure aluminum was produced according to the equation

$$AlCl_3(l) + 3\ Na(l) \rightarrow Al(s) + 3\ NaCl(s) \qquad \Delta_r H = -564.8\ kJ$$

$\frac{-564.8\ kJ}{3} = -188.3\ kJ$

4. The reaction above can also be written as

A. $AlCl_3(l) + 3\ Na(l) + 564.8\ kJ \rightarrow Al(s) + 3\ NaCl(s)$
B. $AlCl_3(l) + 3\ Na(l) \rightarrow Al(s) + 3\ NaCl(s) + 564.8\ kJ$
C. $1/3\ AlCl_3(l) + Na(l) + 188.3\ kJ \rightarrow 1/3\ Al(s) + NaCl(s)$
D. $1/3\ AlCl_3(l) + Na(l) \rightarrow 1/3\ Al(s) + NaCl(s) + 188.3\ kJ$

Use the following information to answer the next question.

Standard Heats of Formation

Substance	$\Delta H_f°$ (kJ/mol)
X	–22.5
Y	+78.3
Z	–54.8

$\Delta H = \Sigma p - r$

Given: $X + 3\ Y \rightleftharpoons 2\ Z + 2\ W \qquad \Delta_r H = -562.0\ kJ$

$-562.0kJ = \left[2mol\left(\frac{-54.8kJ}{mol}\right) + 2mol(W)\right] - \left[1mol\left(\frac{-22.5kJ}{mol}\right) + 3mol\left(\frac{+78.3kJ}{mol}\right)\right]$

$-562.0kJ = -109.6kJ + 2W - (212.4kJ)$

$+212.4 \qquad +212.4$

→

$-349.6\text{kJ} = -109.6\text{kJ} + 2W$
$+109.6 \quad +109.6$

$\frac{-240}{2} = \frac{2W}{2}$ $\quad W = -120.0\text{kJ} = 1.20 \times 10^2$

Numerical Response

2. The standard molar heat of formation of substance W is, expressed in scientific notation, ***a.bc*** 10^{d} kJ/mol. The values of ***a***, ***b***, ***c***, and ***d*** are __1__, __2__, __0__, and __2__.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

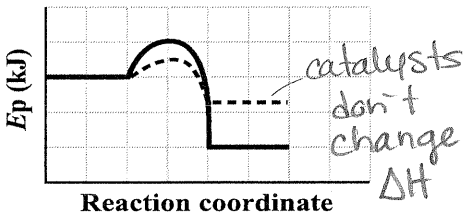
Use the following information to answer the next two questions.

Dr. Richard Trotter has developed what could be the first cost-effective process for limiting methane emissions from underground coal mines. In this process, methane and oxygen are reacted at 800°C in the presence of a catalyst. The products of this process are carbon dioxide gas and liquid water.

combustion = exothermic

5. Which of the following potential energy diagrams represents both the catalyzed (– – –) and uncatalyzed reactions (—) for this process?

A.



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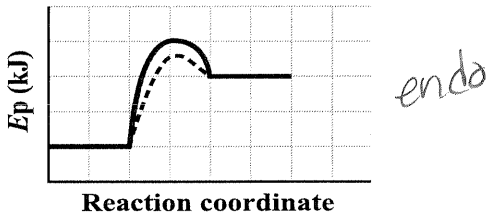
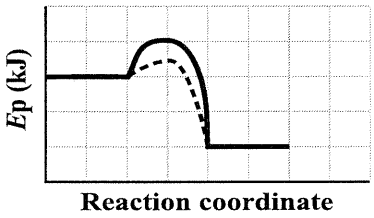
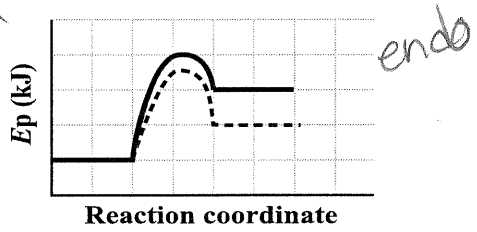


C.



D.



6. The combustion of hydrogen gas as an automobile fuel is an attractive alternative to the combustion of fossil fuels because

A. the fuel tank for hydrogen gas would be smaller
B. burning hydrogen gas forms non-polluting products
C. hydrogen gas is less expensive and is readily available for use not true
D. the molar heat of combustion for hydrogen gas is greater than those of the hydrocarbon fuels X

Use the following information to answer the next question.

Three Equations and Their Enthalpies

$N_2O_5(g) + H_2O(l) \rightarrow 2\,HNO_3(l)$	$\Delta_r H = -76.6$ kJ
$2H_2(g) + O_2(g) \rightarrow 2\,H_2O(l)$	$\Delta_r H = -571.6$ kJ
$N_2(g) + 3\,O_2(g) + H_2(g) \rightarrow 2\,HNO_3(l)$	$\Delta_r H = -348.2$ kJ

Numerical Response

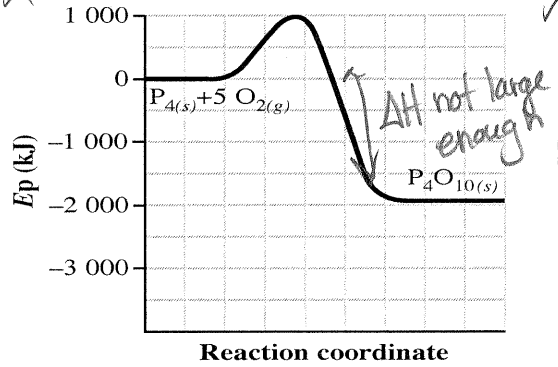
3. Given the equations above, the molar enthalpy of formation for dinitrogen pentaoxide is

Answer: +/– 14.2 **kJ/mol**

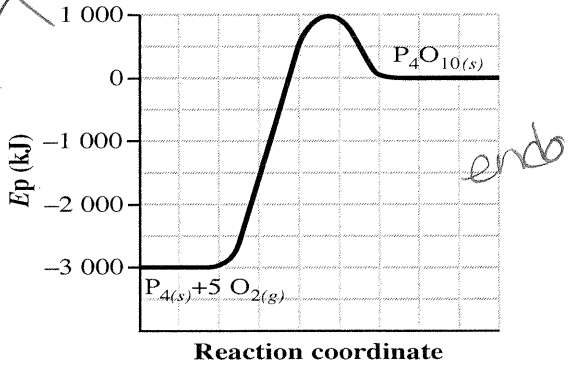
(Record your **four-digit** answer in the numerical response section of your answer sheet.)

7. When phosphorus, $P_4(s)$, is exposed to air, it ignites spontaneously and rapidly releases 2 940 kJ/mol. Which of the following potential energy diagrams best represents this reaction?

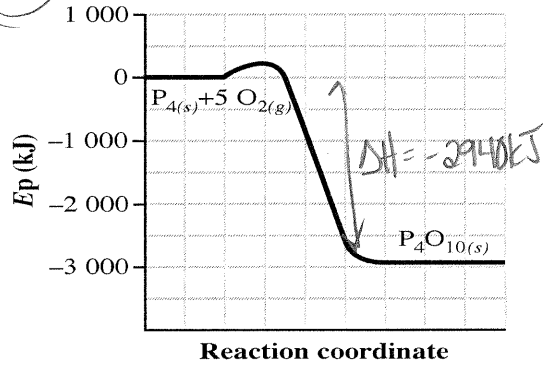
A.



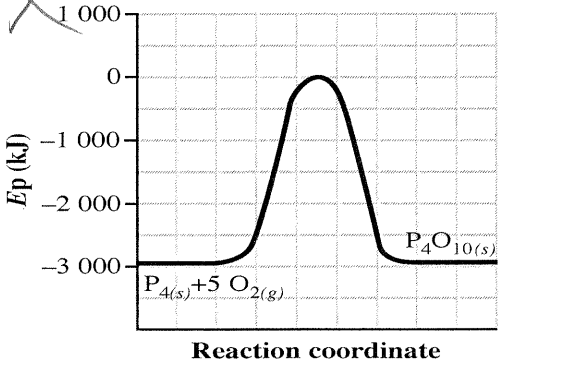
B.



C.



D.



Chemical change = rearrangement of bonds = change in E_p

8. *The energy changes that occur when propane undergoes combustion are primarily due to changes in* ___***i***___ *energy resulting from* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	kinetic	a rearrangement of bonds
B.	potential	a rearrangement of bonds
C.	kinetic	an increase in molecular motion
D.	potential	an increase in molecular motion

9. An equation that does **not** represent a redox reaction is

A. $2\,\overset{+1\ -2}{H_2O}(aq) \rightarrow 2\,\overset{0}{H_2}(g) + \overset{0}{O_2}(g)$

B. $2\,\overset{+1}{Ag^+}(aq) + \overset{0}{Cu}(s) \rightarrow \overset{+2}{Cu^{2+}}(aq) + 2\,\overset{0}{Ag}(s)$

C. $C_3H_8(g) + 5\,\overset{0}{O_2}(g) \rightarrow 3\,\overset{+4\ -2}{CO_2}(g) + 4\,\overset{+1\ -2}{H_2O}(g)$

D. $\overset{+2\ +5\ -2}{Ba(NO_3)_2}(aq) + \overset{+1\ +6\ -2}{Na_2SO_4}(aq) \rightarrow \overset{+2\ +6\ -2}{BaSO_4}(s) + 2\,\overset{+1\ +5\ -2}{NaNO_3}(aq)$ — no change in ox #'s ∴ not redox

Use the following information to answer the next question.

Leaching technology is used in the mining and refining of copper ore. In the first step of the leaching process, concentrated aqueous sulfuric acid flows through a copper ore deposit. Solid copper(II) oxide reacts with sulfuric acid as represented by the following net ionic equation.

$\overset{+2}{CuO}(s) + 2\,H^+(aq) \rightarrow \overset{+2}{Cu^{2+}}(aq) + H_2O(l)$

The resulting solution that contains copper(II) ions is transferred to an electrolytic cell where pure copper is produced.

10. In the reaction represented by the equation above, copper undergoes

A. reduction only (ox # would decrease)

B. oxidation only (ox # would increase)

C. both oxidation and reduction (disproportionation)

D. neither oxidation nor reduction

11. The equation representing a spontaneous reaction at standard conditions is

A. $\overset{OA}{Co^{2+}}(aq) + 2\,\overset{RA}{Fe^{2+}}(aq) \rightarrow Co(s) + 2\,Fe^{3+}(aq)$ non-spont

B. $\overset{OA}{Sn^{4+}}(aq) + 2\,\overset{RA}{Br^-}(aq) \rightarrow Sn^{2+}(aq) + Br_2(l)$ non-spont

C. $2\,\overset{RA}{I^-}(aq) + \overset{OA}{Cl_2}(g) \rightarrow I_2(s) + 2\,Cl^-(aq)$ ✓ OA above RA

D. $Pb(s) + \underset{RA}{Fe^{2+}}(aq) \rightarrow Pb^{2+}(aq) + \underset{OA}{Fe}(s)$ non-spont

OA + RA = spontaneous

Use the following information to answer the next question.

Cellular Respiration

$$\overset{0\ +1\ -2}{C_6H_{12}O_6}(s) + 6\ \overset{0}{O_2}(g) \rightleftharpoons 6\ \overset{+4\ -2}{CO_2}(g) + 6\ \overset{+1\ -2}{H_2O}(l)$$

oxidized: $0 \rightarrow +4$ = RA

reduced: $0 \rightarrow -2$ = OA

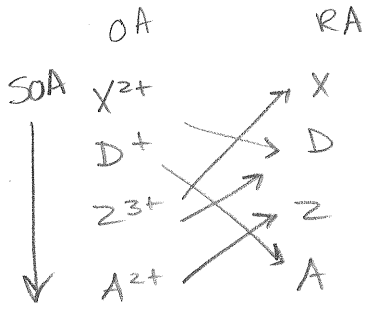
12. During cellular respiration, the oxidizing agent is

A. $O_2(g)$
B. $CO_2(g)$
C. $H_2O(l)$
D. $C_6H_{12}O_6(s)$

Use the following information to answer the next question.

The reactions below involve hypothetical metals and metallic ions.

Reaction	Observation
$Z^{3+}(aq) + X(s)$	no evidence of reaction ✗
$X^{2+}(aq) + D(s)$	evidence of reaction ✓
$D^{+}(aq) + A(s)$	evidence of reaction ✓
$Z^{3+}(aq) + D(s)$	no evidence of reaction ✗
$A^{2+}(aq) + Z(s)$	no evidence of reaction ✓



13. The order of oxidizing agents, from strongest to weakest, is

A. $Z^{3+}(aq), X^{2+}(aq), A^{2+}(aq), D^{+}(aq)$
B. $X^{2+}(aq), D^{+}(aq), Z^{3+}(aq), A^{2+}(aq)$
C. $A^{2+}(aq), Z^{3+}(aq), D^{+}(aq), X^{2+}(aq)$
D. $X^{2+}(aq), Z^{3+}(aq), A^{2+}(aq), D^{+}(aq)$

one species is both oxidized + reduced

14. Which of the following equations represent a disproportionation reaction?

A. $2\ \overset{0}{Na}(s) + \overset{0}{I_2}(s) \rightarrow 2\ \overset{+1\ -1}{NaI}(s)$
B. $2\ \overset{0}{F_2}(g) + \overset{0}{O_2}(g) \rightarrow 2\ \overset{+2\ -1}{OF_2}(g)$ ← exception *
C. $\overset{0}{Cl_2}(aq) + H_2O(l) \rightarrow \overset{+1\ -2\ +1}{HOCl}(aq) + H^{+}(aq) + \overset{-1}{Cl^{-}}(aq)$ — Cl_2 is oxidized + reduced
D. $2NH_3(aq) + NaOCl(aq) \rightarrow N_2H_4(aq) + NaCl(aq) + H_2O(l)$

$-3 \quad +1 \quad -2 \quad -1$

Numerical Response

4. Nitrogen forms a number of oxides. Examples include $NO(g)$, $N_2O(g)$, $NO_2(g)$, and $N_2O_5(g)$. The oxidation number of nitrogen in each compound listed above is, respectively, __2__, __1__, __4__, and __5__.

(Record your **four-digit answer**.)

+2 -2 +1 -2 +4 -2 +5 -2

$2(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O(a))$

$5(HOOCCOOH \rightarrow 2CO_2(g) + 2H^+ + 2e^-)$

Use the following information to answer the next three questions.

$5HOOCCOH + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2(g)$

Poisonous oxalic acid is found in non-toxic concentrations in vegetables such as spinach and rhubarb. Manufacturers of spinach juice are required to analyze the concentration of oxalic acid to avoid problems that could arise from unexpectedly high concentrations of oxalic acid. The reaction of oxalic acid with acidified potassium permanganate can be represented by the following unbalanced equation:

$$5\ HOOCCOOH(aq) + 2\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 10\ CO_2(g)$$

The following results were obtained from a titration using 0.13 mol/L $KMnO_4(aq)$ to titrate 10.00 mL samples of oxalic acid of unknown concentration.

Trial Number	**1**	**2**	**3**	**4**
Final Buret Reading (mL)	17.55	25.40	41.65	15.85
Initial Buret Reading (mL)	0.30	10.05	26.40	0.55
Volume of $KMnO_4(aq)$	17.25	15.35	15.25	15.30
Final Colour	purple	pink	pink	pink

average = 15.30mL

15. The balanced equation for the titration is

A. $6\ HOOCCOOH(aq) + 2\ MnO_4^-(aq) + 5\ H^+(aq) \rightarrow 10\ Mn^{2+}(aq) + 2\ H_2O(l) + 8\ CO_2(g)$

B. $5\ HOOCCOOH(aq) + 2\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 10\ CO_2(g)$

C. $2\ HOOCCOOH(aq) + 5\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 10H_2O(l) + 8\ CO_2(g)$

D. $HOOCCOOH(aq) + MnO_4^-(aq) + 16\ H^+(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + 2CO_2(g)$

Numerical Response

5. The concentration of oxalic acid in the sample used in the titration, expressed in scientific notation, is $a.bc\ 10^{-d}$ mol/L. The values of ***a***, ***b***, ***c***, and ***d*** are __4__, __9__, __7__, and __1__.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

$5HOOCCOOH + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

$V = 10.0mL$ $C = 0.13mol/L$

$C = ?$ $V = 15.30mL$

$$15.30mL \times \frac{0.13mol}{L} \times \frac{5mol\ HOOCCOOH}{2mol\ MnO_4^-} \times \frac{1}{10.0mL} = 0.49725mol/L = 4.97 \times 10^{-1}$$

Use the following information to answer the next question.

$$\_\_OCl^-(aq) + \_\_I^-(aq) + 2H^+(aq) \rightleftharpoons \_\_I_2(aq) + \_\_Cl^-(aq) + \_\_H_2O(l)$$

16. *When the equation above is balanced under acidic conditions, the whole number coefficient for $H^+(aq)$ is* ___i___ *and the amount of electrons transferred is* ___ii___ .

The statement above is completed by the information in row

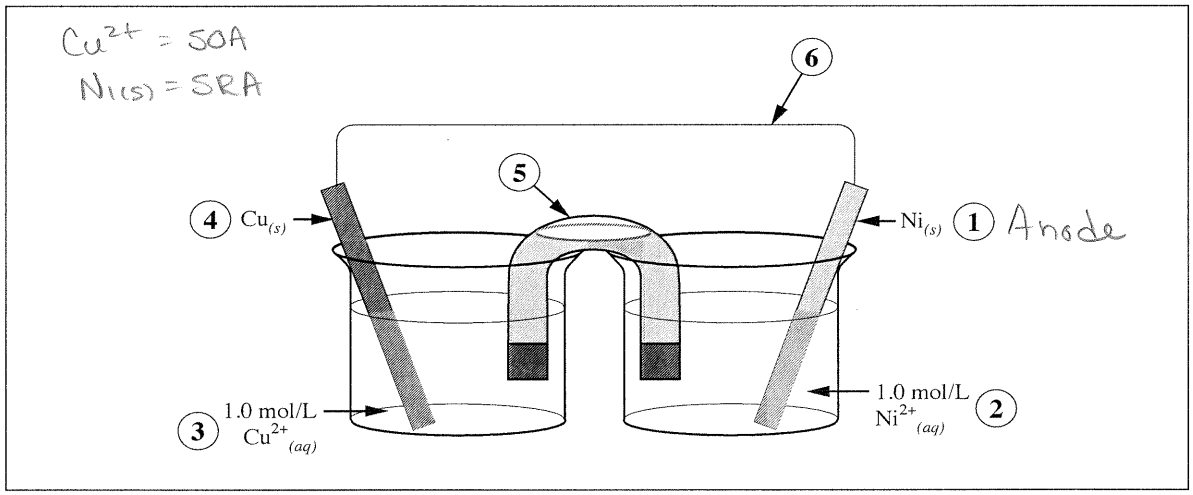
Row	*i*	*ii*
A.	2	2 mol
B.	2	1 mol
C.	1	2 mol
D.	1	1 mol

$2I^- \rightarrow I_2 + 2e^-$

$2e^- + 2H^+ + OCl^- \rightarrow Cl^- + H_2O$

$2OCl^- + 2I^- + 2H^+ \rightleftharpoons I_2 + Cl^- + H_2O$

Use the following information to answer the next question.



Numerical Response

6. Identify the part of the electrochemical cell, as numbered above, that corresponds to the terms listed below.

Anode	1	(Record in the **first** column) ($Ni_{(s)}$)
Cathode	4	(Record in the **second** column) ($Cu_{(s)}$)
Oxidizing agent	3	(Record in the **third** column) ($Cu^{2+}_{(aq)}$)
External electron circuit	6	(Record in the **fourth** column)

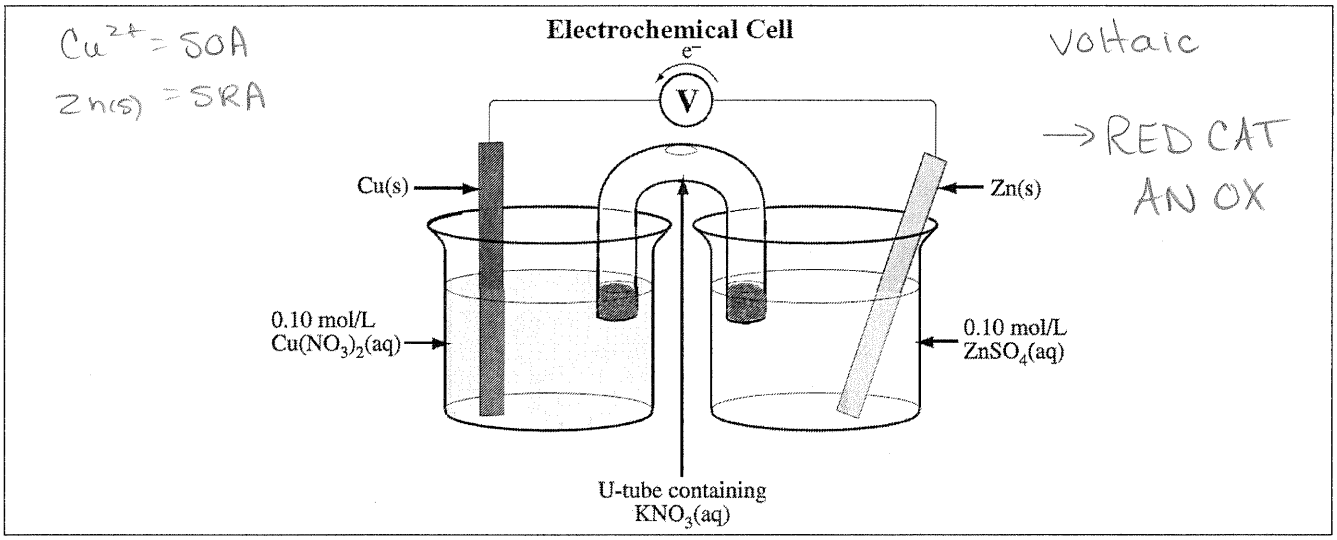
(Record your **four-digit answer** in the numerical-response section.)

17. An electrolytic cell differs from a voltaic cell in that the electrolytic cell

non-spont
- needs power supply

A. is spontaneous ✗
B. consumes electricity ✓
C. has an anode and a cathode (both voltaic + electrolytic do)
D. has a positive $E°_{net}$ value – neg

Use the following information to answer the next question.



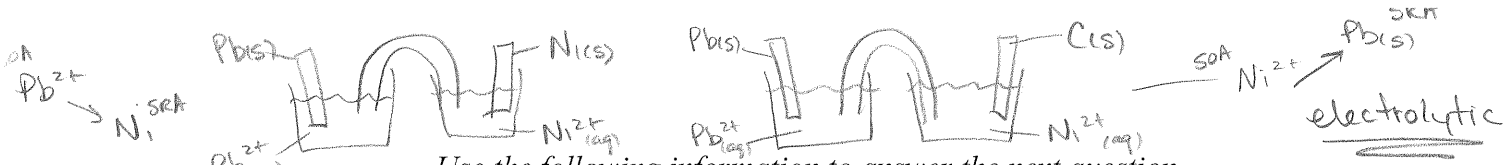
18. *The reduction half-reaction that occurs during the operation of the electrochemical cell represented in the diagram above is* ___***i***___ *, and this reaction occurs at the* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	anode
B.	$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	cathode
C.	$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	anode
D.	$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	cathode

(red) $Cu^{2+} + 2e^- \rightarrow Cu(s)$

(ox) $Zn \rightarrow Zn^{2+} + 2e^-$



Use the following information to answer the next question.

Cell #1 Cell #2

A student constructed two standard electrochemical cells using $Pb^{2+}(aq)$ and $Ni^{2+}(aq)$. In both cells a Pb(s) electrode was placed in the $Pb^{2+}(aq)$ solution. In the first cell a Ni(s) electrode was placed in the $Ni^{2+}(aq)$ solution. In the second cell an inert C(s) electrode was placed in the $Ni^{2+}(aq)$ solution instead of the Ni(s) electrode.

Draw both out!

19. Which of the following statements describes what occurs in each cell?

only #1

A. In ~~both cells a spontaneous reaction~~ occurs and Pb(s) is produced.

B. In both cells a ~~power source is needed~~. only #2

C. In the first cell the reaction is spontaneous, and in the second cell the reaction is nonspontaneous.

D. In the first cell ~~Ni(s) is produced~~, and in the second cell a power source is needed.

lead is produced

Use the following information to answer the next question.

During the operation of a NiCad battery, the two half-reactions that occur are

anode	**I**	$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$	$E°_r = ?$ V
cathode	**II**	$NiO_2(s) + 2H_2O(l) + 2e- \rightarrow Ni(OH)2(s) + 2OH^-(aq)$	$E°_r = -0.49$ V

On discharging, the electrical potential of a NiCad battery is +1.40 V

Numerical Response

7. The reduction potential for half-reaction I is $-$ 1.89 V.

$E°_{cell} = E°_{r\,cathode} - E°_{r\,anod}$

$1.40 = -0.49 - x$

$x = -1.89V$

(Record your **three-digit answer** in the numerical-response section.)

20. If the $Cu^{2+}(aq)$ / Cu(s) reduction half-reaction was assigned a reduction potential value of 0.00 V for an electrode potential table, then the $Ni^{2+}(aq)$ / Ni(s) half-reaction on that table would have a reduction potential value of

A. +0.26 V
B. +0.08 V
C. –0.26 V
D. –0.60 V

$Cu^{2+} + 2e^- \rightleftharpoons Cu(s)$ $\quad +0.34 \xrightarrow{-0.34} 0.00V$

$Ni^{2+} + 2e^- \rightleftharpoons Ni(s)$ $\quad -0.26 \xrightarrow{-0.34} -0.60V$

$Cr^{2+} + 2e^- \rightarrow Cr(s)$
2000A m = 112g

Use the following information to answer the next two questions.

A chromium electroplating cell needs to operate at a current of 2000 A to plate 112 g of chromium onto a car bumper.

Numerical Response

8. In order to plate the bumper, the number of moles of chromium (II) ions that must react in the cell is _____ mol.

(Record your **three-digit answer** in the numerical-response section.)

$112g \times \frac{mol}{52.00g} = 2.15 mol\ Cr$

*Use your recorded answer for **Numerical Response 8** to answer **Multiple Choice 21**.*

21. In order to plate the bumper, the cell must operate for

A. 208 min.
B. 104 min.
C. 3.46 min.
D. 1.73 min.

$112g \times \frac{mol}{52.00g} \times \frac{2 mole^-}{1 mole\ Cr} \times \frac{9.65 \times 10^4 C}{mole^-} \times \frac{s}{2000 C} \times \frac{1 min}{60 s}$

$= 3.46 min$

Use the following information to answer the next question.

Sacrificial metals may be used to protect pipelines, septic tanks, and ship propellers.

22. A metal that could be used as a sacrificial anode to protect iron is

A. magnesium
B. silver
C. lead
D. tin

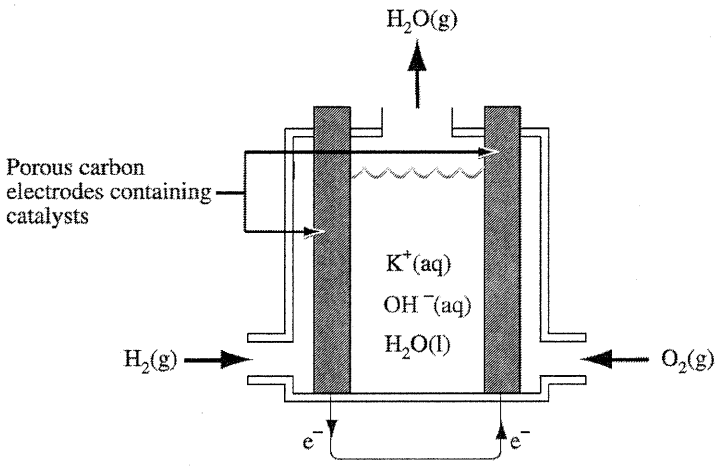
(B, C, D: weaker RAs (above Fe on chart))

↳ need RA stronger than Fe(s)
∴ it gets oxidized instead

Use the following information to answer the next question.

Hydrogen–oxygen fuel cells have been used for years in spacecraft and more recently in small-scale power plants to generate electricity. Now, some governments and companies are working together to perfect this type of fuel cell for automobile use, and experiments are currently being conducted with operational prototypes. A diagram of a hydrogen–oxygen fuel cell is shown below.

Hydrogen-Oxygen Fuel Cell



23. From an ecological perspective, a reason why hydrogen–oxygen fuel cells should **not** be used to power automobiles is that

A. hydrogen fuel can be produced through the electrolysis of seawater by using the energy produced from burning fossil fuels should not

B. cars powered by a hydrogen–oxygen fuel cell would be up to 30 more efficient than cars powered by gasoline should

C. water vapour is the primary by-product of the cell should

D. oxygen is readily available from the atmosphere should

24. Which of the following chemical compounds is **not** considered an organic compound?

A. $C_2H_5COOCH_3(l)$ ester

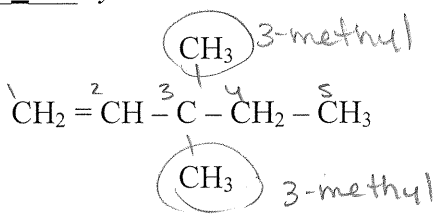
B. $C_6H_5COOH(s)$ acid

C. $CH_3CH_2OH(l)$ alcohol

D. $NH_4CN(s)$

Not – cyanides
– oxides of C
– carbonates
– carbides

25. *The correct IUPAC name for the following compound is* ___i___ *and it can be classified as a/n* ___ii___ *hydrocarbon.*



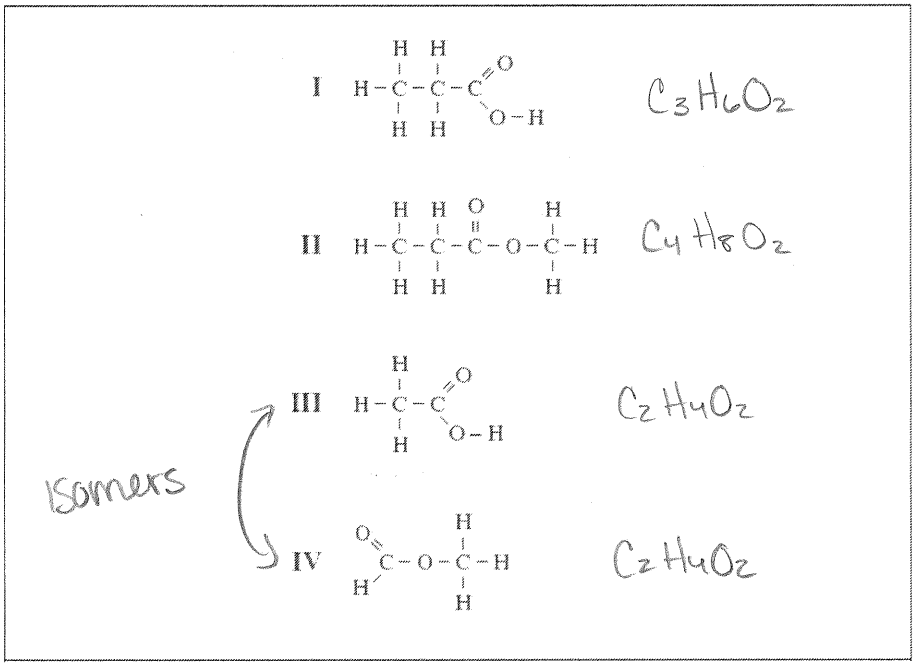
double bond gets priority

The statement above is completed by the information in row

Row	*i*	*ii*
A.	3,3-dimethylpent-4-ene	saturated
B.	3,3-dimethylpent-1-ene	unsaturated
C.	3-ethyl-3-methylbutene	saturated
D.	propylpent-4-yne	unsaturated

(alkanes: — single bonds only)
= or ≡

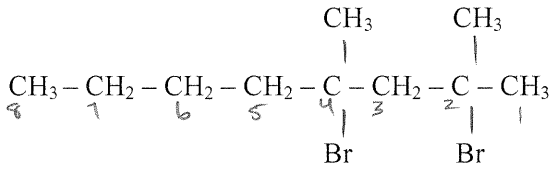
Use the following information to answer the next question.



26. Which of the structural diagrams numbered above represent isomers?

A. I and II
B. I and IV
C. II and III
D. III and IV

Use the following information to answer the next question.



2,4-dibromo-2,4-dimethyloctane

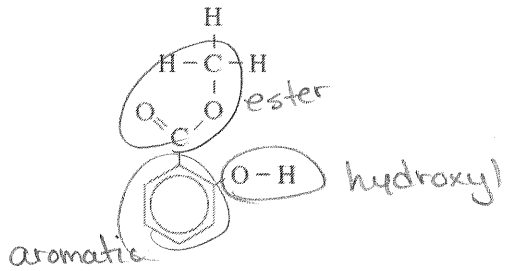
Numerical Response

9. The above compound is named 2, 4-dibromo-2, 4-dimethyloctane:

(Record your **four-digit answer**).

Use the following information to answer the next question.

The structural diagram of the active ingredient in many pain-relief medications is shown below.



27. *The structural diagram above represents an* ___***i***___ *compound that contains a* ___***ii***___ *and an* ___***iii***___ *functional group.*

The statement above is completed by the information in row

Row	*i*	*ii*	*iii*
A.	aliphatic	carboxyl	alkene
B.	aromatic	carboxyl	alkene
C.	aromatic	hydroxyl	ester
D.	aliphatic	hydroxyl	ester

28. Which of the following alcohols has the *highest* boiling point?

all alcohols = choose largest molecule
most C's + H's = most e⁻'s = ↑ London force

A. 

B. 

C. 

D. 

Use the following information to answer the next question.

An economically important reaction involving the fossil fuel propane is represented by the following equation.

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$ + energy

29. *During this* ___i___ *reaction, energy is* ___ii___ *the surroundings.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	combustion	released to
B.	combustion	absorbed from
C.	elimination	released to
D.	elimination	absorbed from

Use the following information to answer the next question.

Common Organic Reactions

sat'd

1 $C_2H_5OH(l) \rightarrow C_2H_4(g) + H_2O(l)$ elimination

2 $C_6H_6(l) + Cl_2(l) \rightarrow C_6H_5Cl(l) + HCl(g)$ substitution (product + leftovers)

3 $C_3H_6(g) + H_2(g) \rightarrow C_3H_8(g)$ – addition (one product)

4 $CH_3CH_2COOH(l) + CH_3OH(l) \rightarrow CH_3CH_2COOCH_3(l) + H_2O(l)$ – esterification

Numerical Response

10. Match each equation representing the reactions numbered above with the type of below reaction it exemplifies below.

Addition	3	(Record in the **first** column)
Substitution	2	(Record in the **second** column)
Elimination	1	(Record in the **third** column)
Esterificaton	4	(Record in the **fourth** column)

Use the following information to answer the next question.

The plastic used in packaging film and bottles is produced in a two-step reaction from petroleum. Its manufacture can be represented as follows:

Step 1

$C_nH_{2n+2} \xrightarrow{catalyst} CH_2 = CH_2$

alkane → alkene = cracking (large molecules are broken down into smaller ones)

Step 2

$CH_2 = CH_2 \xrightarrow{catalyst} \ldots CH_2 - CH_2 - CH_2 - CH_2 - \ldots$

30. *The process shown in Step 1 is known as* ___***i***___, *while the reaction shown in Step 2 occurs by* ___***ii***___.

The statement above is completed by the information in row

Row	*i*	*ii*
A.	cracking	~~condensation~~ polymerization
B.	cracking	addition polymerization
C.	reforming	~~condensation~~ polymerization
D.	~~reforming~~	addition polymerization

31. A chemical equilibrium system is always characterized by

A. the presence of equal amounts of reactants and products ✗ not necessary
B. the completion of a chemical reaction when changes cease to occur ✗ particles still moving
C. equal amounts of reactants and products entering and being removed from the system ✗ closed
D. the conversion of reactants to products occurring at the same rate as the conversion of products to reactants

Use the following information to answer the next two questions.

Nitrogen monoxide, an atmospheric pollutant, forms in automobile engines. The equilibrium law expression is:

$$K_c = \frac{[NO(g)]^2}{[N_2(g)]\,[O_2(g)]}$$

[products] / [reactants]

32. The reaction described by this equilibrium is

A. $NO(g) \rightleftharpoons N_2(g) + O_2(g)$
B. $N_2(g) + O_2(g) \rightleftharpoons NO(g)$
C. $N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$
D. $2\,NO(g) \rightleftharpoons N_2(g) + O_2(g)$

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

$\frac{10\,mol}{50\,L} = 0.20\,mol/L$

33. Under certain conditions, the K_c is 650. Initially, a 50 L gas tank contains 10 mol each of $N_2(g)$ and $O_2(g)$. Calculate the equilibrium concentration of NO(g).

A. 19 mol/L
B. 9.3 mol/L
C. 0.37 mol/L
D. 0.19 mol/L

perfect square

	$N_{2(g)}$	+ $O_{2(g)}$	$\rightleftharpoons 2NO_{(g)}$
I	0.20	0.20	0.00
C	−x	−x	+2x
E	0.20−x	0.20−x	2x

$650 = \frac{(2x)^2}{(0.20-x)^2}$

$25.49509 = \frac{2x}{(0.20-x)}$

$5.09901 - 25.49509x = 2x$

$\frac{5.09901}{27.49509} = \frac{27.49509x}{27.49509}$

$x = 0.18545$

$2x = 0.37$

Use the following information to answer the next question.

Some toothpastes contain sodium bicarbonate. Acid in the saliva reacts with the sodium bicarbonate according to the equilibrium equation:

$$HCO_3^-(aq) + H_3O^+(aq) \rightleftharpoons 2\,H_2O(l) + CO_2(g)$$

0 → 3

34. In the reaction represented above, the amount of $CO_2(g)$ produced could be increased by

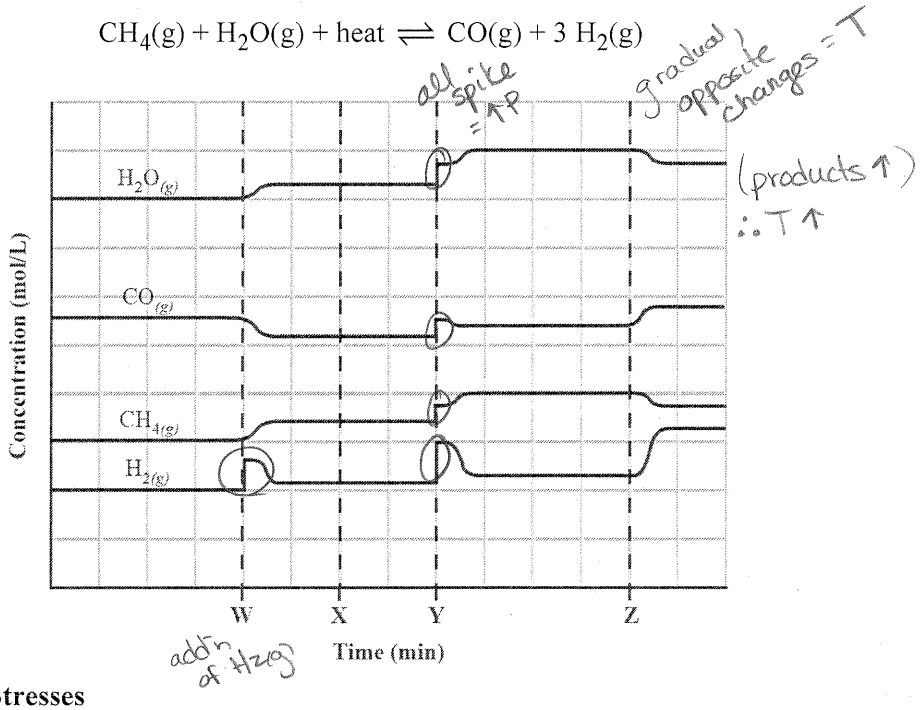
A. decreasing the volume in order to increase the pressure ✗ ↑P = ↓P system = move to side w/ less moles = ←
B. increasing the $H_3O^+(aq)$ concentration ✓
C. adding a catalyst ✗
D. raising the pH

↓$[H_3O^+]$ = shift left

Use the following information to answer the next question.

Manipulations of an Equilibrium System

$$CH_4(g) + H_2O(g) + \text{heat} \rightleftharpoons CO(g) + 3\,H_2(g)$$



Stresses

1. Addition of heat
2. Addition of neon while a constant volume is maintained (no effect)
3. Addition of hydrogen
4. Pressure increased by decreasing the volume

Numerical Response

11. Match each of the stresses identified above with the letter on the graph that indicates the time at which the stress was applied.

	W	X	Y	Z
Stress applied:	3	2	4	1
Time:	↑ H_2	no effect	↑P	heat ↑

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Numerical Response

12. The concentration of $H_3O^+(aq)$ ions in a bottle of wine is 3.2×10^{-4} mol/L. The pH of this wine is 3.49.

$pH = -\log[3.2 \times 10^{-4}) = 3.49485 = 3.49$

(Record your **three-digit** answer in the numerical response section of your answer sheet.)

Use the following information to answer the next question.

$$\underset{1}{HSO_4^-(aq)} + \underset{2}{HCOO^-(aq)} \rightleftharpoons \underset{3}{HCOOH(aq)} + \underset{4}{SO_4^{2-}(aq)}$$

Numerical Response

13. Match each acid or base in the forward reaction, as numbered above, with the corresponding term below.

acid	1	(Record in the **first** column)
conjugate base	4	(Record in the **second** column)
base	2	(Record in the **third** column)
conjugate acid	3	(Record in the **fourth** column)

35. An equilibrium that would favour the products is

A. $NH_4^+(aq) + H_2PO_4^-(aq) \rightleftharpoons NH_3(aq) + H_3PO_4(aq)$

B. $HCN(aq) + HS^-(aq) \rightleftharpoons CN^-(aq) + H_2S(aq)$

C. $HSO_4^-(aq) + HSO_3^-(aq) \rightleftharpoons H_2SO_3(aq) + SO_4^{2-}(aq)$

D. $HF(aq) + HCO_3^-(aq) \rightleftharpoons F^-(aq) + H_2CO_3(aq)$

A above B

SA above SB = favour products

Use the following equation to answer the next two questions.

$$HNO_2(aq) + H_2BO_3^-(aq) \rightleftharpoons NO_2^-(aq) + H_3BO_3(aq)$$

36. The amphiprotic species in the reaction is

can accept or donate H^+

A. $H_2BO_3^-(aq)$

H ~ can donate (−) neg charge ~ can accept

B. $H_3BO_3(aq)$

C. $HNO_2(aq)$

D. $NO_2^-(aq)$

$[H_3O^+] = 10^{-pH} = 10^{-2.95} = 0.001122018\,5\,mol/L$

37. A 0.100 mol/L propanoic acid solution, $C_2H_5COOH(aq)$, has a pH of 2.95. From these data, the K_b for the propanoate ion, $C_2H_5COO^-(aq)$ is

A. 1.1×10^{-3}
B. 1.3×10^{-5}
C. 7.9×10^{-10}
D. 8.7×10^{-12}

$C_2H_5COOH + H_2O_{(l)} \rightleftharpoons C_2H_5COO^- + H_3O^+_{(aq)}$

0.100	0	0
$-x$	$+x$	$+x$
$0.100-x$	x	x
$=0.0988779$		$=0.001122$

$K_a = \frac{(0.00112200)}{0.0988779} = 1.2732 \times 10^{-}$

$K_b = \frac{K_w}{K_a}$

$= 7.854 \times 10^{-1}$

$= 7.9 \times 10^{-10}$

Use the following information to answer the next two questions.

Municipal swimming pool water is treated with chlorine compounds that have the ability to kill harmful bacteria. To assure safe, appropriate levels of these chlorine compounds, a pH range of 7.2 to 7.8 is essential. Within this pH range, the equilibrium:

$$H_2O(l) + HOCl(aq) \rightleftharpoons H_3O^+(aq) + OCl^-(aq)$$

maintains approximately equal concentrations of HOCl(aq) and $OCl^-(aq)$.

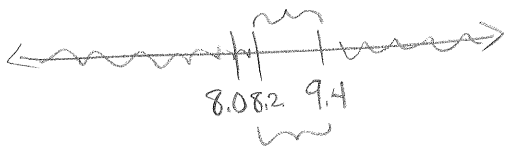
38. Samples of pool water were tested with several acid-base indicators. The results are shown in the following table:

Indicator	Colour
thymolphthalein	colourless
phenol red	red
phenolphthalein	light pink

less than or equal to 9.4
greater than or equal to 8.0
b/w 8.2 - 10.0

The pH of this pool water is approximately

~~A.~~ 7.0
B. 8.7
~~C.~~ 10.1
~~D.~~ 13.5



Numerical Response

14. The pH of a sample of 0.020 mol/L HOCl(aq) used in treating pool water is 4.55. K_a (from data book) $= 4.0 \times 10^{-8}$ check approx rule $\frac{(0.020)}{4.0 \times 10^{-8}} > 1000$ ✓

(Record your **three-digit** answer in the numerical response section of your answer sheet.)

$HOCl + H_2O_{(l)} \rightleftharpoons H_3O^+ + OCl^-$

0.020	0	0
$-x$	$+x$	$+x$
$0.020-x$	x	x
by approx. rule $\hookrightarrow 0.020$		

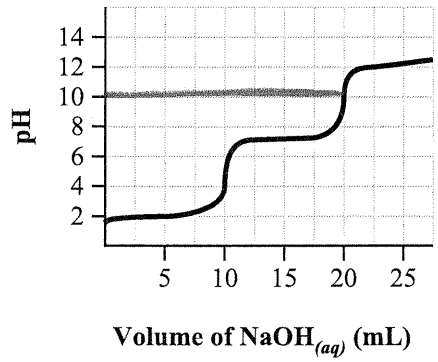
$4.0 \times 10^{-8} = \frac{x^2}{0.020}$

$x = 2.828 \times 10^{-5} = [H_3O^+]$

$pH = -\log(2.828 \times 10^{-5}) = 4.5484$

Use the following information to answer the next two questions.

A student sketched a titration curve based on data collected during a reaction between 0.050 mol/L NaOH(aq) titrant and a 25.0 mL sample of an acid.



pH change @ 2nd equivalence point ~10

39. The most suitable indicator to identify the equivalence point of the second reaction is

A. methyl red 4.8 - 6.0 (too low)
B. methyl orange 3.2 - 4.4 (too low)
C. indigo carmine 11.4 - 13 (too high)
D. phenolphthalein 8.2 - 10.0 just right

40. The possible identity of the acid that was titrated by NaOH(aq) in the graph above is

A. HOOCCOOH(aq) } both polyprotic
B. H_3PO_4(aq)
C. HNO_3(aq) SA
D. HF(aq) WA - not polyprotic

needs to be polyprotic w/ 2 quantitative rxns

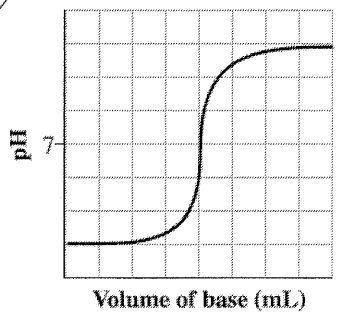
= HOOCCOOH = 2 quantitative rxns = 2 bumps

= H_3PO_4 = 1 quantitative rxn = 1 bump

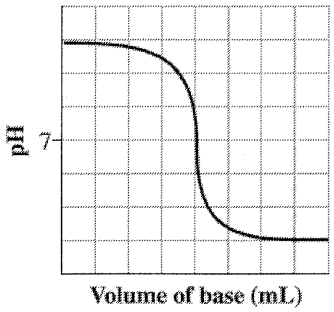
★ OH^- + acids above HSO_3^- = quantitative rxns

41. Which of the following diagrams represents the titration of a strong acid with a strong base?

A.

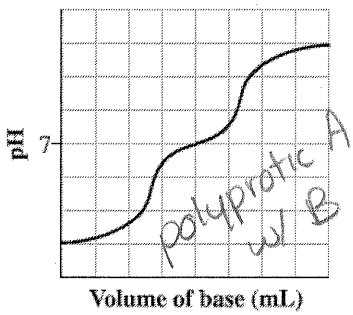


B.



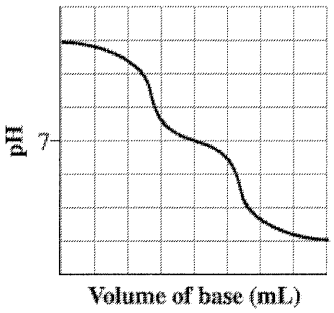
SB w/ SA

C.



polyprotic A w/ B

D.



polyprotic B w/ A

Use the following information to answer the next question.

Acid-base reactions are critical to maintaining equilibrium within the human body. Orange juice contains sufficient hydronium ions to kill a human if blood were not buffered. A constant pH is maintained by the $H_2PO_4^-(aq)$ / $HPO_4^{2-}(aq)$ buffer system in response to addition of acids like orange juice.

42. The most likely reaction between this buffer system and the $H_3O^+(aq)$ ions in an orange juice solution is

A. $H_3O^+(aq) + HPO_4^{2-}(aq) \rightleftharpoons H_3PO_4(aq) + HOH(l)$

B. $H_3O^+(aq) + H_2PO_4^-(aq) \rightleftharpoons H_3PO_4(aq) + HOH(l)$

C. $H_3O^+(aq) + HPO_4^{2-}(aq) \rightleftharpoons H_2PO_4^-(aq) + HOH(l)$

D. $H_3O^+(aq) + H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + HOH(l)$

H_3PO_4

$H_2PO_4^- + OH^- \rightleftharpoons H_2O + HPO_4^{2-}$

$HPO_4^- + H_3O^+ \rightleftharpoons H_2O + H_2PO_4^-$

buffers addition of acid + base