

SOLUTIONS

Chem 1200b Final Exam

Tuesday, April 12, 2011 3.00 hours



Multiple Choice Section

Section code 000 Exam code 000

Message from the Dean: All answer sheets are subject to a common data analysis which identifies anomalies of statistical significance in the selection of right and wrong answers by pairs of students. The course instructor is required to report all statistically significant results which suggest that cheating may have occurred. All such incidents will be subject to further investigation. All proven cases of cheating will be subject to severe academic penalties. If you are currently seated near someone with whom you studied, and you think you may choose many of the same answers as that person, please raise your hand now and ask a proctor to reseat you.

This test contains 42 multiple-choice questions of equal value. Be sure you have a complete test paper. Scrap paper and a periodic table are attached, and they may be removed for use.

Place your student ID card on your desk.

The only permitted calculator is a Sharp EL-510R(B). No other electronic devices may be in your possession, even for timekeeping purposes. A molecular model kit is permitted, but the sharing of models or model pieces is strictly forbidden.

You are welcome to keep the question booklet and any scrap sheets.

Proctors and instructors will not interpret, translate, clarify, or explain questions, nor will they confirm, verify, or assist you with your answers or your thinking. Therefore, you are not permitted to ask any questions related to the content of the test.

There is no extra time allotted for filling in the Scantron. After the allotted time, everyone must put their pencils down. The Scantron, whether completed or not, will be collected. Under no circumstances will this booklet be used for marking purposes. The answers on your Scantron are considered to be your official answers, so please ensure that you complete your Scantron accurately, and prior to the end of the test. Answers that cannot be read by the Scantron computer will be marked as being incorrect.

If you do not leave before the last 15 minutes, you must stay in your seat until you are dismissed. NO TALKING IS ALLOWED AT ANY TIME.

Before starting the test, be sure that you have correctly entered:

- Your student number
- Section code 000
- Exam code 000

1. For the following reaction:



Which one of A – E represents a system that is closest to being at equilibrium?

	N_2O_4 (kPa)	NO_2 (kPa)
A)	22.1	156
B)	156	22.1
C)	100	200
D)	200	100
E)	100	100

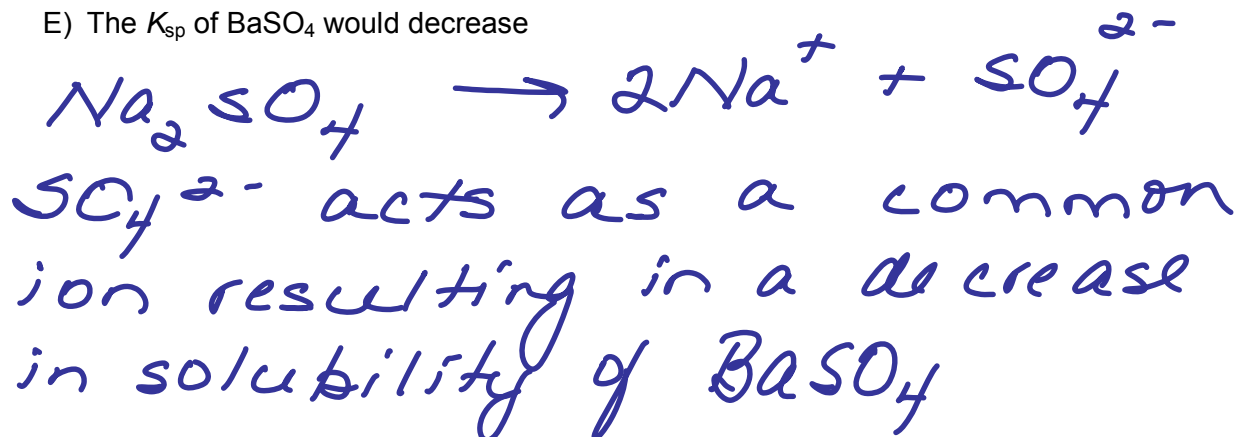
Determine Q :

$$Q = \frac{(P_{\text{NO}_2})^2}{P_{\text{N}_2\text{O}_4}}$$

Q closest to K
is closest to equilibrium

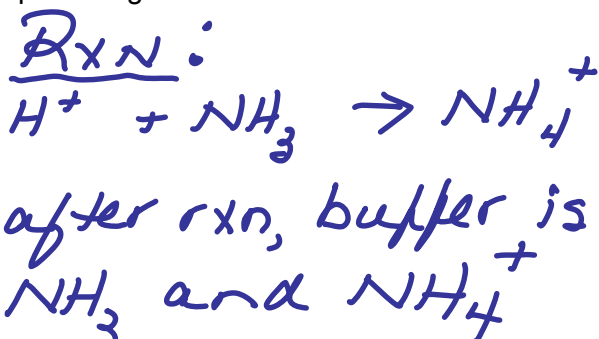
2. Ba^{2+} is an extremely toxic ion. However, BaSO_4 is used as a contrast agent in medical imaging because it is relatively insoluble ($K_{\text{sp}} = 1.5 \times 10^{-9}$). What would happen if we tried to dissolve barium sulfate in an aqueous solution of sodium sulfate instead of in pure water?

- A) The solubility of BaSO_4 would decrease
- B) More sulfate would be produced
- C) The solubility of BaSO_4 would remain the same because K_{sp} is a constant
- D) The solubility of BaSO_4 would increase
- E) The K_{sp} of BaSO_4 would decrease



6. Which one of the following mixtures of 0.1 M HNO₃ and 0.1 M NH₃ is the best buffer? That is, which one is most resistant to pH changes in either direction?

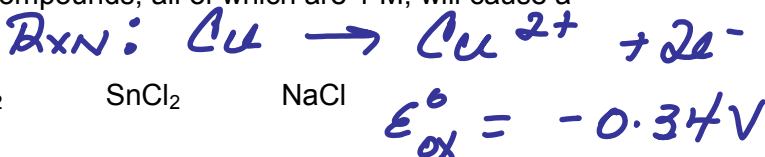
- A) 100 mL of HNO₃ and 200 mL of NH₃
- B) 50 mL of HNO₃ and 200 mL of NH₃
- C) 100 mL of HNO₃ and 250 mL of NH₃
- D) 150 mL of HNO₃ and 200 mL of NH₃
- E) 100 mL of HNO₃ and 100 mL of NH₃



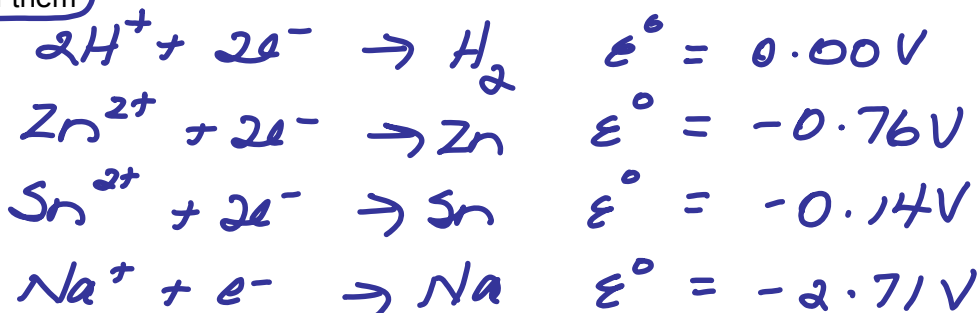
- Best buffer has ratio of NH₃:NH₄⁺ closest to 1:1

7. Which solutions of the following compounds, all of which are 1 M, will cause a copper pipe to dissolve at 25°C?

- HCl ZnCl₂ SnCl₂ NaCl



- A) None of them
- B) 2
- C) 3
- D) 4
- E) 1

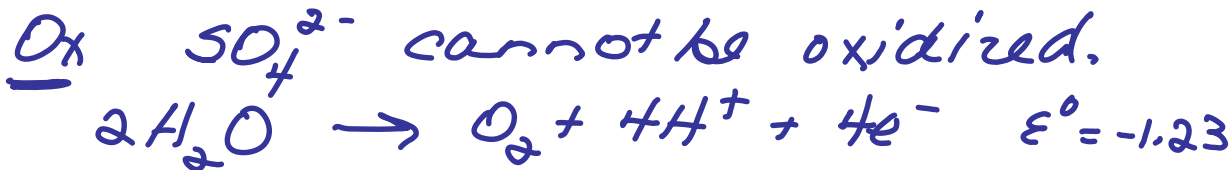
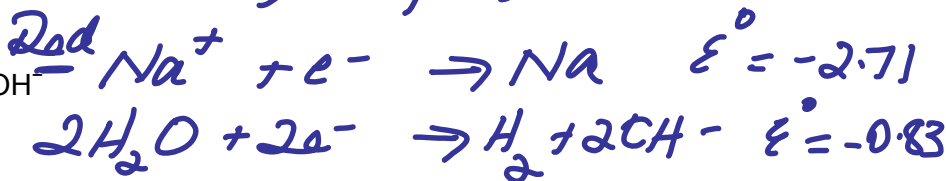


None will result in a +ve E°_{cell}

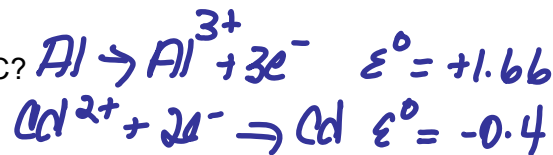
8. If water is electrolyzed in the presence of an inert salt, such as Na₂SO₄, what are the products formed in the overall reaction?

- A) H₂ and O₂
- B) Na and H₂
- C) Na, O₂, and OH⁻
- D) H₂, O₂, H⁺, and OH⁻
- E) Na, S, and H⁺

species present:
 Na^+, SO_4^{2-}, H_2O



9. What will be the voltage of the following cell at 25°C?



$$\varepsilon_{\text{cell}}^\circ = +1.26 \text{ V}$$

A) 1.17

B) 1.35

C) 1.23

D) 1.20

E) 1.26

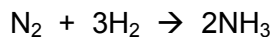


$$n = 6$$

$$\varepsilon_{\text{cell}} = \varepsilon_{\text{cell}}^\circ - \frac{0.0257}{n} \ln Q$$

$$= 1.26 - \frac{0.0257}{6} \ln \frac{[\text{Cd}^{2+}]^3}{[\text{Al}^{3+}]^2}$$

10. Which of the following statements must be correct for the following reaction?



~~X~~ 1. $\frac{\Delta[\text{NH}_3]}{\Delta t} = 2 \frac{\Delta[\text{N}_2]}{\Delta t}$

~~X~~ 2. Rate = $[\text{N}_2][\text{H}_2]^3$

~~X~~ 3. The reaction product has a trigonal planar molecular shape.

A) None of them

B) 1 and 2 only

C) 1 and 3 only

D) 3 only

E) 1 only

11. Using the data below, find the orders for each of reactants A, B, and C. All runs were performed under identical conditions.



$$\text{Rate} = k [A]^x [B]^y [C]^z$$

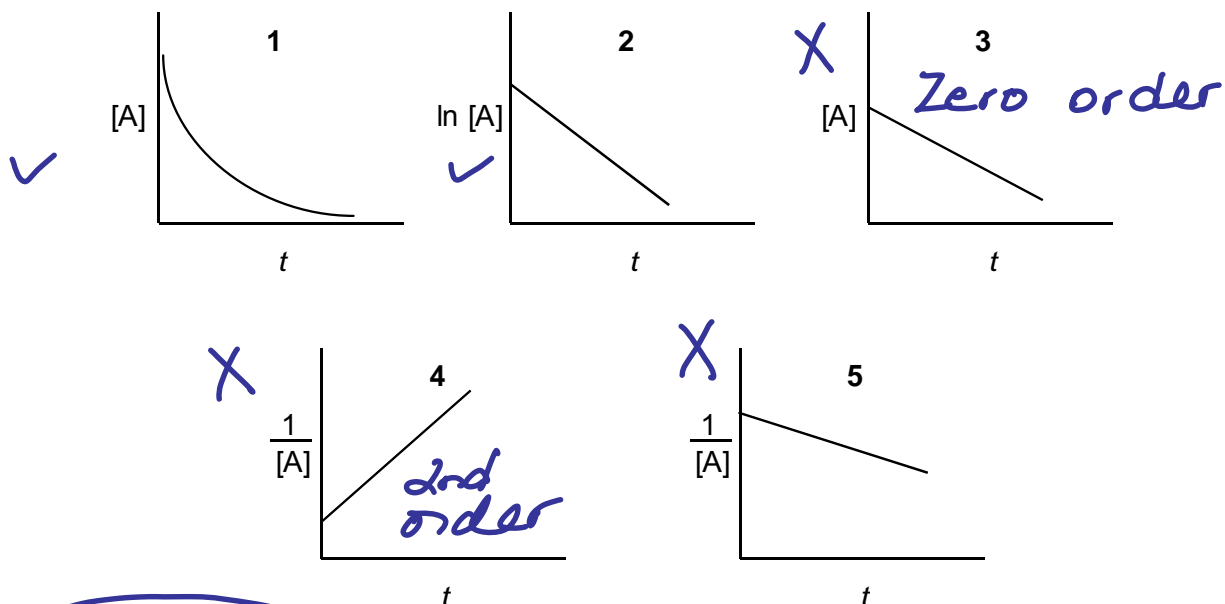
$x=1$ $y=1$ $z=1$

Run	Initial [A]	Initial [B]	Initial [C]	Initial Rate ($M^{-1} s^{-1}$)
1	0.1	0.1	0.3	1.0×10^{-6}
2	0.4	0.1	0.3	4.0×10^{-6}
3	0.1	0.4	0.3	4.0×10^{-6}
4	0.8	0.6	0.6	96×10^{-6}

$4 \Rightarrow 32$ $32 \Rightarrow 48$ $48 \Rightarrow 96$

	A	B	C
A)	1	1	1
B)	2	1	1
C)	1	1	-1
D)	2	1	0
E)	Insufficient data to determine the reactant orders		

12. For the reaction $A \rightarrow \text{products}$ which of the following plots are correct representations for first-order kinetics?



- A) 1 and 2 only
- B) 1, 2, and 4 only
- C) 2 and 4 only
- D) 3 and 4 only
- E) 5 only
13. Technetium 99-m ($t_{1/2} = 6.0$ h) is a commonly used radioisotope for imaging in nuclear medicine. One of the concerns in using any radioactive species is how quickly it loses radioactivity. What percentage of the original ^{99m}Tc would **decay** in 24 hours?

A) 93.75

B) 6.25

C) 25

D) 3.125

E) 87.5

$$\# \text{ half lives} = \frac{24}{6} = 4$$

$$\text{Frac. Left} = (0.5)^4 = 0.0625$$

$$\begin{aligned} \text{Fraction decayed} &= 1 - 0.0625 \\ &= 0.9375 \\ &\Rightarrow 93.75\% \end{aligned}$$

14. In water, ammonium cyanate (NH_4NCO) rearranges to produce urea via second-order kinetics. If it takes 11.6 h for the concentration of NH_4NCO to drop from 0.250 M to 0.0841 M, how fast is NH_4NCO being changed to urea when its concentration is 0.0841 M?

A) 0.00481 M h^{-1}

B) 0.680 M h^{-1}

C) 0.0841 M h^{-1}

D) 0.0939 M h^{-1}

E) 0.00790 M h^{-1}

$$kt = \frac{1}{[A]_t} - \frac{1}{[A]_0}$$

$$k(11.6) = \frac{1}{0.0841} - \frac{1}{0.250}$$

$$k = 0.680 \text{ mol}^{-1} \text{ L hr}^{-1}$$

$$\begin{aligned} \text{Rate} &= k [\text{NH}_4\text{NCO}]^2 \\ &= 0.680 (0.0841)^2 \\ &= 0.00481 \text{ mol L}^{-1} \text{ hr}^{-1} \end{aligned}$$

15. A reaction has an activation energy of 60 kJ mol^{-1} . By what factor would the rate of the reaction increase if the temperature were increased from 0°C to 100°C ?

A) 1188

B) 120

C) 0.0071

D) 60

E) 1.00

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$= \frac{60,000}{8.314} \left(\frac{1}{273.15} - \frac{1}{373.15} \right)$$

$$= 7.080$$

$$\therefore \frac{k_2}{k_1} = e^{7.080} = 1188$$

16. For a given reaction, a plot of $\ln k$ as a function of $1/T$ gives a straight line with a slope of -7869 Kelvin. By what factor would the rate of the reaction increase if a catalyst lowered the activation energy of the reaction to 25.5 kJ mol^{-1} at 25°C ?

A) 9.88×10^6

B) 2.93×10^4

C) 2.46×10^{11}

D) 1.73×10^{77}

E) 2.16×10^{49}

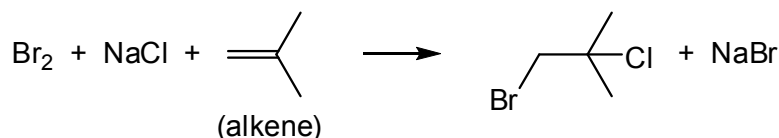
$$-7869 = -E_a/R$$

$$\therefore E_a = 65423 \text{ J mol}^{-1}$$

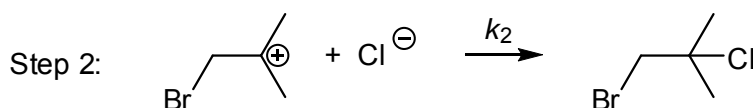
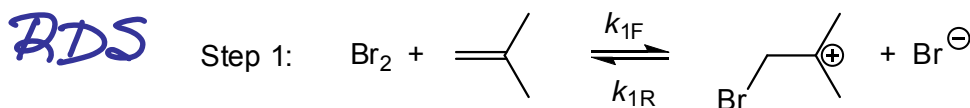
$$\ln \frac{k_2}{k_1} = \frac{65423 - 25500}{8.314 \times 298.15} = 16.105$$

$$\therefore \frac{k_2}{k_1} = e^{16.105} = 9876343$$

17. The reaction



proceeds by the following elementary steps:



If Step 1 is the rate-determining step, what is the rate law for the overall reaction?

A) Rate = $k_{1F}[\text{Br}_2][\text{alkene}]$

B) Rate = $k'[\text{Br}_2][\text{alkene}][\text{Br}^-]$

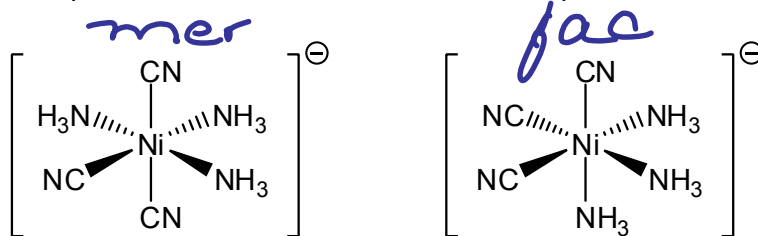
C) Rate = $k'[\text{Br}_2][\text{alkene}][\text{Cl}^-]$

D) Rate = $k'[\text{Br}_2][\text{alkene}][\text{Cl}^-][\text{Br}^-]^{-1}$

E) Rate = $k'[\text{Br}_2][\text{Cl}^-][\text{alkene}]^{-1}$

Use Rate Law
for RDS

18. The two complexes below are best described as a pair of...

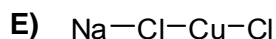
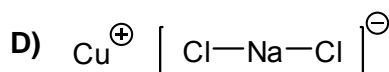
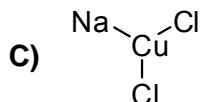
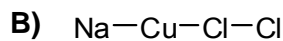
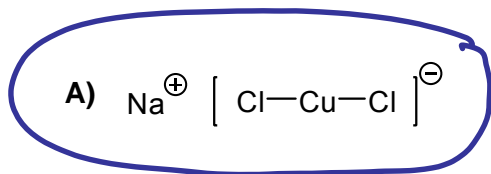


- A) *fac/mer* Isomers
 B) *cis/trans* Isomers
 C) Ionization isomers
 D) Linkage isomers
 E) Constitutional isomers
19. When 1 or 2 of the NH_3 ligands in the octahedral complex $[\text{Co}(\text{NH}_3)_6]^{3+}$ is/are replaced by OH^- , the number of isomers that could be formed are respectively...

	$[\text{Co}(\text{NH}_3)_5\text{OH}]^{2+}$	$[\text{Co}(\text{NH}_3)_4(\text{OH})_2]^+$
A)	1	2
B)	2	1
C)	1	1
D)	2	2
E)	2	3

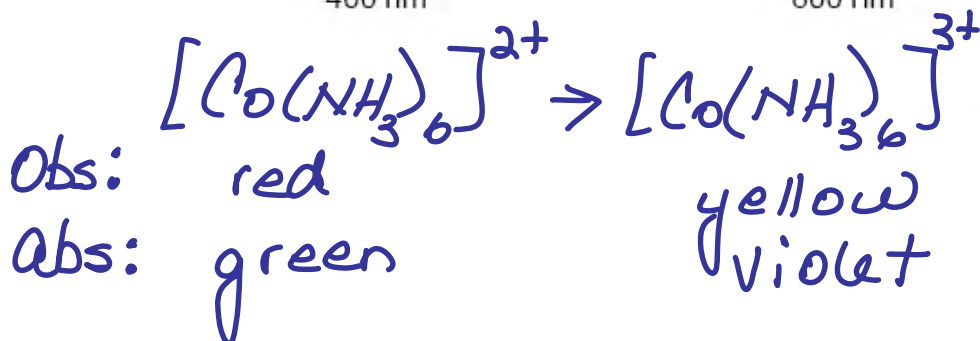
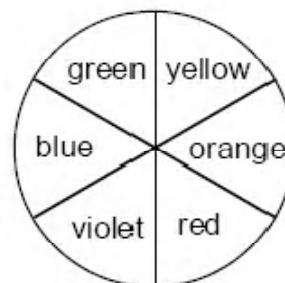
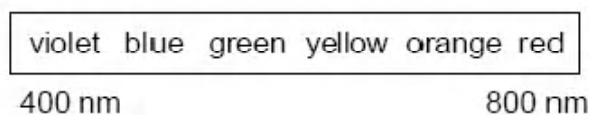
Replace 2
ligands;
can form
cis/trans
isomers

20. Which one of A – E most closely represents the bonding in the complex NaCuCl_2 ?



21. When $[\text{Co}(\text{NH}_3)_6]^{2+}$ is converted to $[\text{Co}(\text{NH}_3)_6]^{3+}$, its colour changes from red to yellow. Which statement best explains this phenomenon? The visible spectrum and the colour wheel are provided below for reference.

- A)** Δ_o increases and $[\text{Co}(\text{NH}_3)_6]^{3+}$ absorbs violet light
B) Δ_o decreases and $[\text{Co}(\text{NH}_3)_6]^{3+}$ absorbs violet light
C) Δ_o increases and $[\text{Co}(\text{NH}_3)_6]^{3+}$ absorbs green light
D) Δ_o decreases and $[\text{Co}(\text{NH}_3)_6]^{3+}$ absorbs green light
E) The larger size of the Co^{3+} ion causes $[\text{Co}(\text{NH}_3)_6]^{3+}$ to absorb yellow light.



$\therefore \Delta_o$ increases

22. If $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ has a high-spin configuration, and $[\text{Fe}(\text{CN})_6]^{3-}$ has a low-spin configuration, which of these statements is/are correct?

1. The oxidation state of iron in these two complexes is different.
2. The electronic configuration of iron in $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ violates Hund's Rule.
3. The ligand CN^- creates a larger Δ_o .

A) 3 only

B) 2 only

C) 1 and 2 only

D) 2 and 3 only

E) All of them

23. Which one of A – E is not present in the compound shown below?

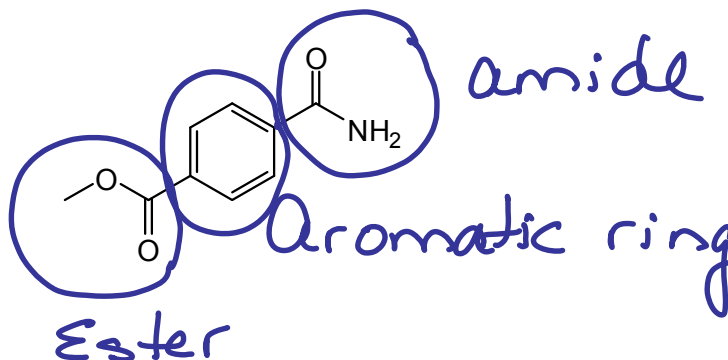
A) Ketone

B) Aromatic ring

C) Ester

D) Amide

E) Carbonyl group



24. Which statement about IR spectroscopy is least likely to be correct?

A) Infrared light travels at a lower speed than UV light.

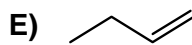
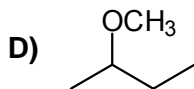
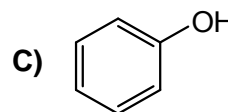
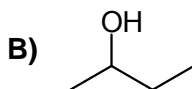
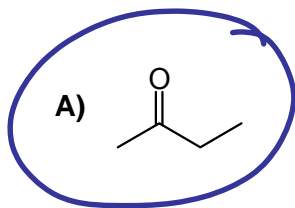
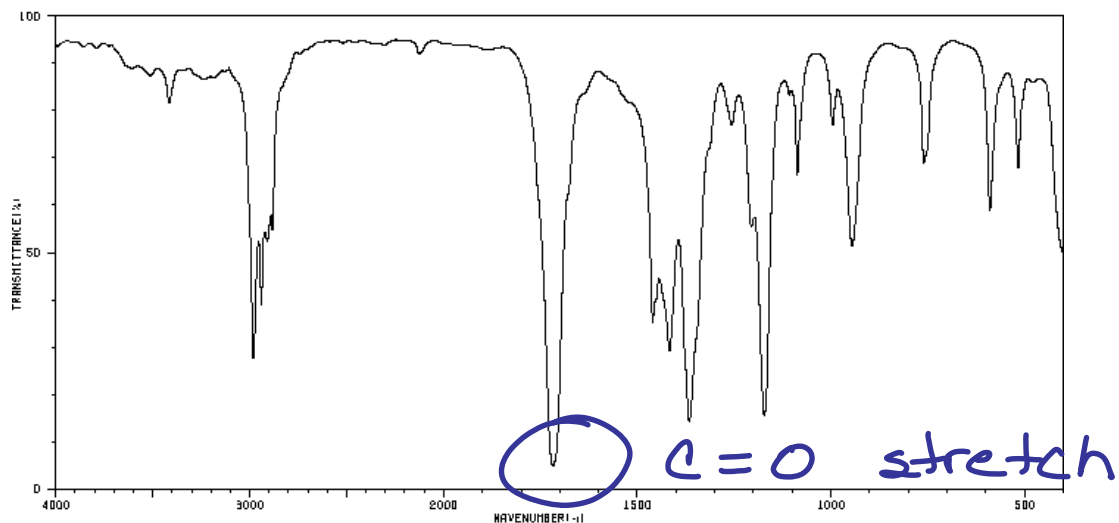
B) A stronger bond between two elements will absorb IR light at a higher frequency than a weaker bond between the same two elements.

C) A bond absorbs IR energy when the frequency of the IR light matches the vibrational frequency of that bond.

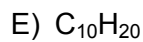
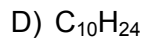
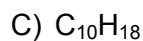
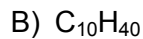
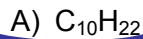
D) The CH bond of an alkyne absorbs at a higher frequency than that of an alkene.

E) Energy is directly proportional to wavenumber.

25. The IR spectrum shown below corresponds to which one of A – E?



26. Which one of A – E is does not contain any rings or π bonds?



\therefore no units of unsaturation
- must be an acyclic alkane; $C_n H_{2n+2}$

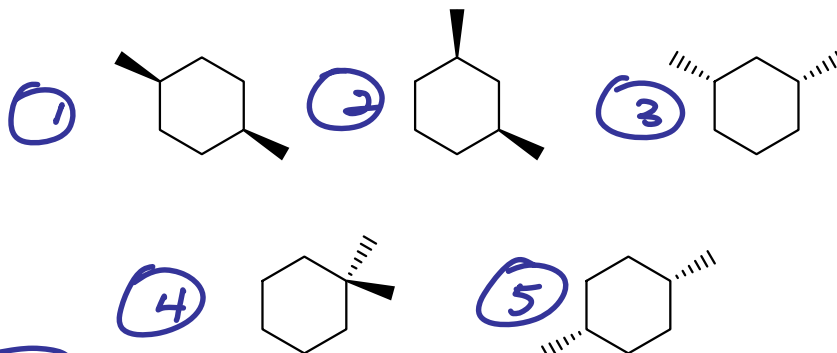
27. The two structures shown below are best described by which of A – E?



Formula
is C_6H_{14}

- A) They are constitutional isomers
 B) They are different conformations of the same compound
 C) They are enantiomers
 D) They are *cis/trans* isomers
 E) They are identical

28. How many different compounds are represented by the five structures below?



- A) 3
 B) 1
 C) 2
 D) 4
 E) 5

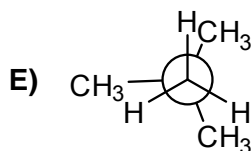
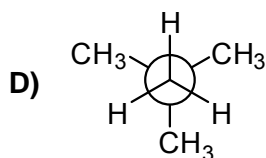
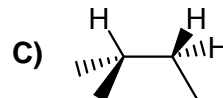
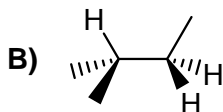
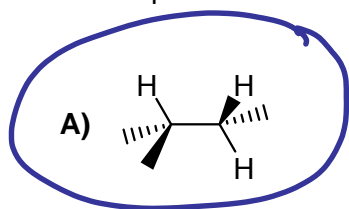
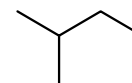
① and ⑤ are identical

② and ③ are identical

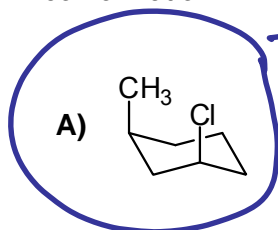
④ is unique

∴ 3 different compounds

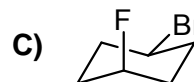
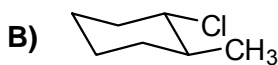
29. Which one of A – E represents the most stable conformation of the compound shown on the right?



30. Which one of A – E does NOT show the molecule in its most stable conformation?



-both substituents axial.



31. How many units of unsaturation are present in benzo[α]pyrene, a carcinogenic compound formed when barbequing?

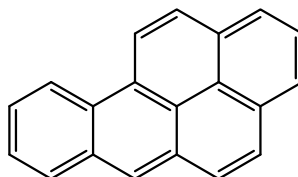
A) 15

B) 10

C) 11

D) 12

E) 13



5 rings
10 π bonds } 15 units of unsaturation

32. How many constitutional isomers of dichlorocyclopentane exist, and how many of those constitutional isomers exhibit *cis/trans* isomerism?

A) 3 constitutional isomers exist, 2 of which exhibit *cis/trans* isomerism

B) 3 constitutional isomers exist, all 3 of which exhibit *cis/trans* isomerism

C) 2 constitutional isomers exist, both of which exhibit *cis/trans* isomerism

D) 2 constitutional isomers exist, 1 of which exhibits *cis/trans* isomerism

E) 2 constitutional isomers exist, none of which exhibit *cis/trans* isomerism

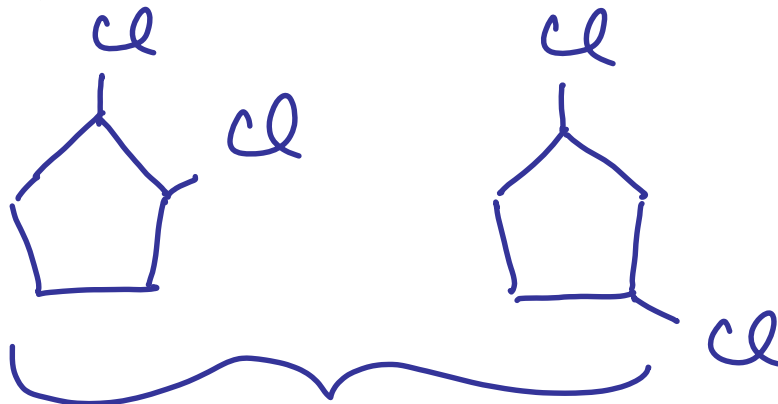
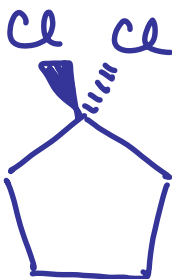
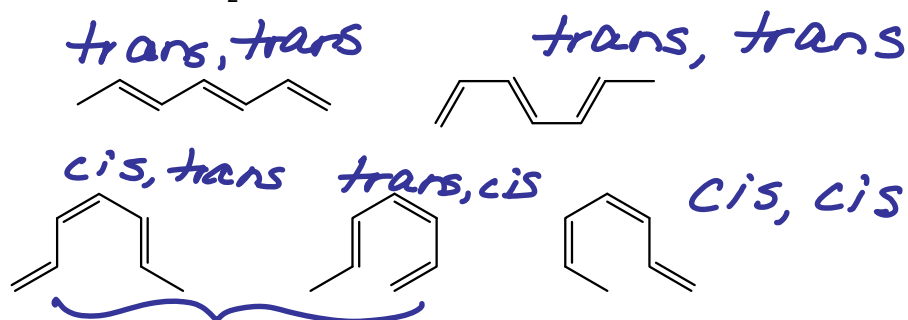


exhibit *cis/trans*
isomerism

33. How many of the following structures represent different stereoisomers of $\text{CH}_3\text{CH}=\text{CHCH}=\text{CHCH}=\text{CH}_2$?



same as molecule is drawn backwards

- A) 3
 B) 1
 C) 2
 D) 4
 E) 5

34. Which statement about chiral molecules is least likely to be correct?

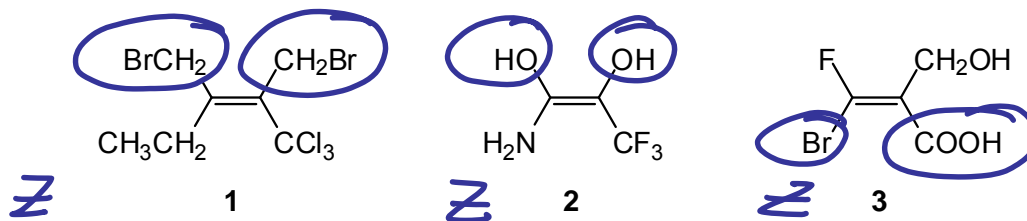
- A) A chiral molecule is superimposable on its mirror image. ✗
 B) A chiral molecule can rotate the plane of polarized light. ✓
 C) A chiral molecule can be optically active. ✓
 D) A chiral molecule does not have a plane of symmetry. ✓
 E) The mirror image of a chiral molecule is a different molecule. ✓

35. Which one of the following molecules is chiral?

- A) CHFBrCl
 B) CH_2FBr
 C) Cyclohexane
 D) 1,2-Dichloroethane
 E) H_2O

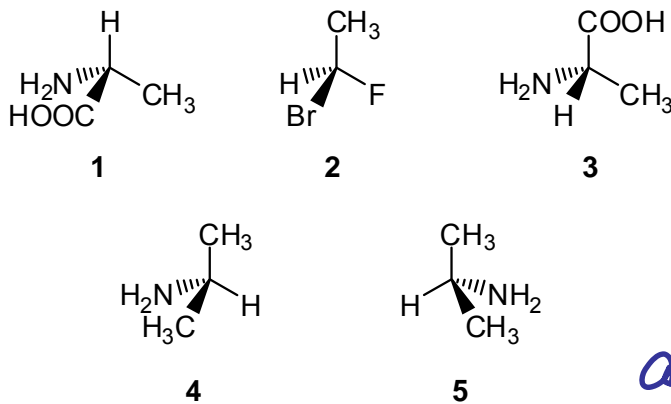
@ bonded to 4 different groups

36. What are the configurations of the alkenes shown below?



	1	2	3
A)	Z	Z	Z
B)	E	Z	E
C)	E	E	Z
D)	Z	E	E
E)	E	E	E

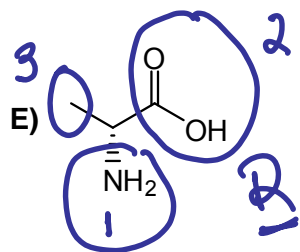
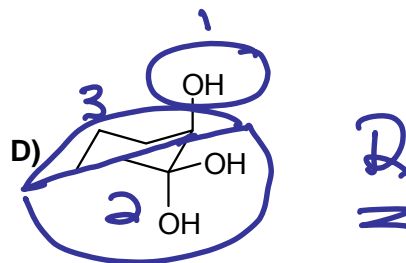
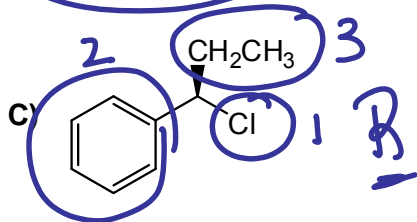
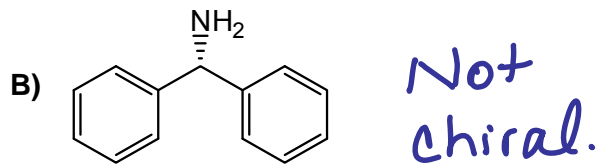
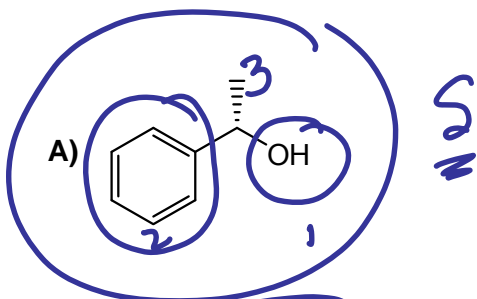
37. Which two molecules represent a pair of enantiomers?



④ + ⑤
all not
chiral

- A) 1 and 3
B) 1 and 2
C) 2 and 3
D) 4 and 5
E) 3 and 4

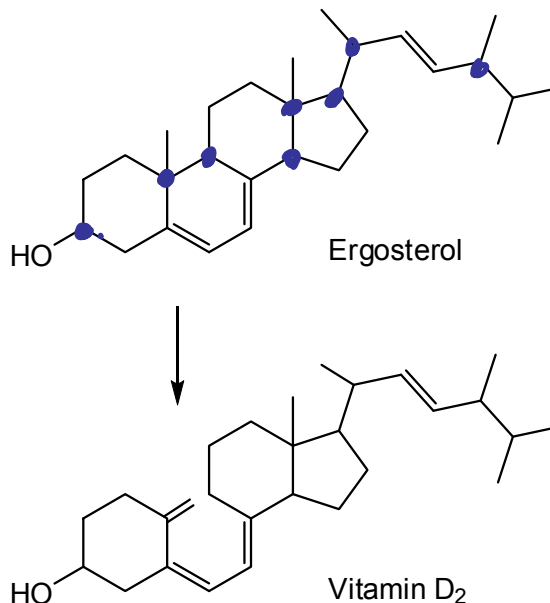
38. Which one of the following has an *S* configuration?



39. When we are exposed to UV light, such as from the sun or a tanning bed, ergosterol is converted to Vitamin D₂, as shown on the right.

Which one of statements A – E is correct?

- A) Ergosterol has a greater number of stereoisomers than does Vitamin D₂.
 B) The two compounds are stereoisomers of each other.
 C) Both compounds are phenols.
 D) Four sp^3 carbons are converted to sp^2 carbons.
 E) Vitamin D₂ has a greater number of units of unsaturation.



40. Refer again to Question 39. How many chiral carbons are present in ergosterol?

- A) 8
 B) 7
 C) 9
 D) 10
 E) 11

Chiral carbons indicated by •

All answers accepted; none were correct

41. Which one of A – E best defines the term *electrochemical series*?

- A) The ranking of different species with respect to reduction potential
- B) The battery formed by connecting many voltaic cells in series.
- C) The ability of ligands to change the value of Δ_o .
- D) The relationship between atomic mass and the strength of a reducing agent.
- E) A measurement of the conductivity of various substances.

42. Which piece of laboratory apparatus shown in the box below is used to most accurately dispense small volumes of liquid?

- A) 2
- B) 1
- C) 3
- D) 4
- E) 5

