Questions

1. What is the oxidation state of chlorine in each of the following substances?

$K\underline{Cl}O_3$ $\quad$ $I\underline{Cl}$ $\quad$ $S_2\underline{Cl_2}$

A -1, 0, +2 $\quad$ B -1, +1, +2 $\quad$ C +5, -1, -1 $\quad$ D +5, -1, +1 $\quad$ E +5, +1, +2

2. In which reaction is hydrogen the oxidising agent?
   - A. $H_2 + Cl_2 \longrightarrow 2HCl$
   - B. $C_2H_4 + H_2 \longrightarrow C_2H_6$
   - C. $N_2 + 3H_2 \longrightarrow 2NH_3$
   - D. $2Na + H_2 \longrightarrow 2NaH$
   - E. $2H_2 + O_2 \longrightarrow 2H_2O$

3. Which compound contains two different elements with identical oxidation states?

A. HClO $\quad$ B. $HClO_4$ $\quad$ C. $Mg(OH)_2$ $\quad$ D. Na_2SO_4 $\quad$ E. NH_4Cl

4. Which reaction is not an oxidation-reduction reaction?
   - A. $Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2$
   - B. $2Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$
   - C. $S + O_2 \longrightarrow SO_2$
   - D. $SO_2 + NO_2 \longrightarrow SO_3 + NO$
   - E. $SO_3 + H_2O \longrightarrow H_2SO_4$

5. Acidified potassium permanganate, $KMnO_4$, reacts with iron(II) ethanedioate, FeC_2O_4. The reactions taking place are shown.

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$
$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$
$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$$

Choose the amount in moles of FeC_2O_4 that react with **one** mole of $KMnO_4$?

A. 0.60 $\quad$ B. 1.67 $\quad$ C. 2.00 $\quad$ D. 2.50 $\quad$ E. 5.00

6. Which is the pH of a 200 mL 0.15 mol L^{-1} HNO_3?

A. -0.52   B. 0.52   C. -0.82   D. 0.82   E. 1.52

7. What is the OH^- concentration of a solution having pH 4.2?

A. 6.31×10^{-5} B. 1.58×10^{-5} C. 6.31×10^{-10} D. 1.58×10^{-9} E. 1.58×10^{-10}

8. 0.23 mol L^{-1} solutions of each of the following conduct electricity. Which is the poorest conductor?

A. HF   B. NH_4F C. NaOH   D. HCOONa   E. HCl

9. What is the concentration of the solution that results from mixing 40.0 mL of 0.200 mol L^{-1}HCl with 60.0 mL of 0.100 mol L^{-1} NaOH?
   A. 0.150 mol L^{-1} NaCl
   B. 0.0400 mol L^{-1} NaCl and 0.0200 mol L^{-1} NaOH
   C. 0.0200 mol L^{-1} NaCl and 0.0200 mol L^{-1} HCl
   D. 0.0200 mol L^{-1} NaCl and 0.0600 mol L^{-1} HCl
   E. 0.0600 mol L^{-1} NaCl and 0.0200 mol L^{-1} HCl

10. Which ions are present at concentrations of at least 0.15 mol L^{-1} -in a solution prepared by mixing 30.0 mL of 0.20 mol L^{-1} $Ca(NO_3)_2$ and 15.0 mL of 0.50 mol L^{-1} NaCl.?

I. Ca^{2+} II. Cl^- III. NO_3^-

A. Only II   B. Both I and II   C. Both I and III   D. Both II and III   E. I, II and III

11. 1.034 g **impure** oxalic acid ($H_2C_2O_4$) is dissolved in water. An appropriate indicator is added, and the solution is titrated with 0.485 mol L^{-1} NaOH. Reaction occurs according to the equation below. 34.47 mL of the NaOH is required to reach the equivalence point.

$$H_2C_2O_4(aq) + 2OH^-(aq) \longrightarrow C_2O_4^{2-}(aq) + 2H_2O(l)$$

What is the **mass** of the oxalic acid in the sample? $M(H_2C_2O_4) = 90.0 \text{ g mol}^{-1}$

A. 0.547 g   B. 0.654 g   C. 0.729 g   D. 0.752 g   E. 0.856 g

12. What is the pH of a solution that results from mixing of 45.0 mL of 0.10 mol L^{-1} HNO_3, 50.0 mL of 0.20 mol L^{-1} HCl and 55.0 mL of 0.10 mol L^{-1} CH_3COOH?

A. 0.40   B. 0.88   C. 1.01   D. 1.18   E. 1.52

13. A mixture of hydrogen and oxygen is ignited and reacts completely to form water. Which mixture will NOT produce 18 g of H_2O?

A. 2.0 g H_2 and 16.0 g O_2 B. 2.0 g H_2 and 18.0 g O_2 C. 2.0 g H_2 and 32 g O_2

D. 4.0 g H_2 and 16.0 g O_2 E. 4.0 g H_2 and 18.0 g O_2

14. An unknown metal nitrate solution contains one of the metal cations below. Identify the cation based on the tests and observations below.

Test	Observation
Add 2 drops NaOH(*aq*)	• forms a white precipitate
Add excess NaOH(*aq*)	• precipitate remains
Add H_2SO_4(*aq*) to a new sample	• forms a colourless solution

A. Na^+ B. Mg^{2+} C. Ba^{2+} D. Zn^{2+} E. Al^{3+}

15. Which combination of substances in aqueous solution will not produce a precipitate?

A. $NaOH + HClO_4$ B. $K_2CO_3 + CuSO_4$ C. $BaBr_2 + Na_2SO_4$
D. $ZnI_2 + KOH$ E. $AgNO_3 + HCl$

16. Phosphoric acid can be manufactured according to the following reaction:

$$Ca_3(PO_4)_2 + 3SiO_2 + 5C + 5O_2 + 3H_2O \longrightarrow 3CaSiO_3 + 5CO_2 + 2H_3PO_4$$

Reaction of equal masses of calcium phosphate ($M = 310$ g mol^{-1}) and silica, SiO_2 (M= 60.0 g mol^{-1}) with excess carbon, oxygen and water gives 1000 kg of phosphoric acid (M= 98.0 g mol^{-1}) Assuming 100% yield, what mass of calcium phosphate was used?

A. 610 kg B. 800 kg C. 920 kg D. 1580 kg E. 3160 kg

17. A sample of potassium oxide, K_2O, is dissolved in 250 mL of distilled water. 25.0 mL of this solution is titrated with 2.00 mol L^{-1} sulfuric acid. 15.0 mL of the sulfuric acid is needed for complete neutralisation.
Which mass of potassium oxide was originally dissolved in 250 mL of distilled water?

$M(K_2O) = 94.2$ g mol^{-1}

… A. 2.83 g B. 5.66 g C. 28.3 g D. 47.1 g E. 56.6 g

18. 25.00 mL of each of the following solutions is added to separate 20 g samples of solid $MgCO_3$. Assuming complete reaction, which solution will produce the largest volume of CO_2 at room temperature and pressure? $M(MgCO_3) = 84.3$ g mol^{-1}

A. 1 mol L^{-1} H_2SO_4 B. 2 mol L^{-1} H_2SO_4 C. 2 mol L^{-1} HNO_3
D. 2 mol L^{-1} HCl E. 3 mol L^{-1} HCl

19. Choose the mass of $Sr(OH)_2.8H_2O$ (M = 265.76 g mol^{-1}) is needed to prepare 250.0 mL of solution in which c(OH^-) is 0.100 mol L^{-1}.

A. 3.32 g B. 6.64 g C. 9.97 g D. 13.3 g E. 26.6 g

20. Upon complete combustion, a 10.0 g sample of a compound containing only carbon, hydrogen and oxygen forms 23.98 g CO_2 and 4.91 g H_2O. What is the empirical formula of the compound?

A. CH_2O_2 B...C_2HO C. C_3H_3O D. $C_6H_3O_2$ E. C_6H_6O

21. Use the given information to calculate the mass of butane (C_4H_{10}) that releases 10,000 kJ of heat energy on combustion. $M(C_4H_{10}) = 58.0\ g\ mol^{-1}$ $\Delta_cH(\text{butane}) = -2877\ kJ\ mol^{-1}$

A. 3.48 g B. 16.7 g C. 172 g D. 195 g E. 202 g

22. Heating 2.00 mol of hydrogen and 3.00 mol of iodine in a 1.00 L sealed container at a fixed temperature results in the reaction below. The mixture of gases at equilibrium contains 2.40 mol of iodine.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Calculate the equilibrium constant, K_c.

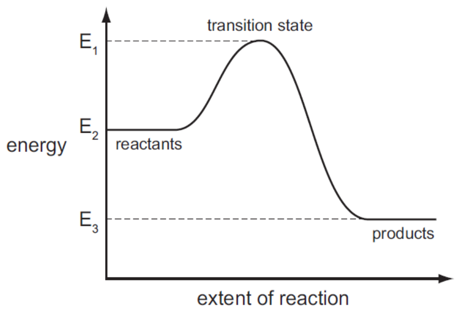
A. 0.107 B. 0.357 C. 0.429 D. 2.33 E. 9.35

23. Which statements about the collision theory of reactions are correct?

I. Only collisions where molecules have the correct orientations lead to reactions.
II. Only collisions with an energy greater than a certain value lead to reactions.
III. Reactions occur faster at higher temperatures because the particles are moving faster and with more energy.

A. I only B. II only C. III only D. II and III only E. I, II and III

24. The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A. $E_1 - E_2$ B. $E_1 - E_3$ C. $E_2 - E_1$ D. $E_2 - E_3$ E. $E_3 - E_2$

25. The reaction between sulfur dioxide and oxygen is reversible

$$2SO_2(g) + O_2(g) \rightleftharpoons SO_3(g) \qquad \Delta_rH^o = -196\ \text{kJ mol}^{-1}$$

Which changes to the pressure and temperature favour the reverse reaction?

	pressure	temperature
A	Decrease	Increase
B	Decrease	Decrease
C	Increase	Increase
D	Increase	Decrease
E	Constant	Increase

26. The reaction between sulfur dioxide and oxygen occurs according to the following equation.

$$2SO_2(g) + O_2(g) \rightleftharpoons SO_3(g) \qquad \Delta_rH^o = -196\ \text{kJ mol}^{-1}$$

Which change in reaction conditions will ***NOT*** result in a higher equilibrium concentration of SO_3?

A. adding a catalyst
B. increasing the pressure
C. adding more O_2
D. adding more SO_3
E. decreasing the temperature

27. Excess thionyl chloride, $SOCl_2$, can be removed from a reaction mixture by reacting it with water according to the following equation.

$$SOCl_2(l) + H_2O(l) \longrightarrow 2HCl(g) + SO_2(g)$$

Use the following data to calculate Δ_rH^o for this reaction.

	$SOCl_2(l)$	$H_2O(l)$	$HCl(g)$	$SO_2(g)$
Δ_fH^o /kJ mol^{-1}	-245.6	-285.8	-92.3	-296.8

A. -142.3 B. -83.4 C. -50.0 D. + 50.0 E. +142.3

28. A student has an unknown organic substance with the molecular formula $C_6H_{12}O$
Addition of acidified permanganate results in a colourless solution after 2 minutes stirring. Mixing a sample of the unknown with bromine water gives an orange solution. Which is the correct unknown?

A. hex-3-en-1-ol B. 3-methyl-pent-1-en-3-ol C. cyclohexanol
D. cyclohexenol E. 3-methylhexan-2-ol

29. How many structural isomers are there with the formula C_6H_{14}?

A. 4 B. 5 C. 6 D. 7 E. 8

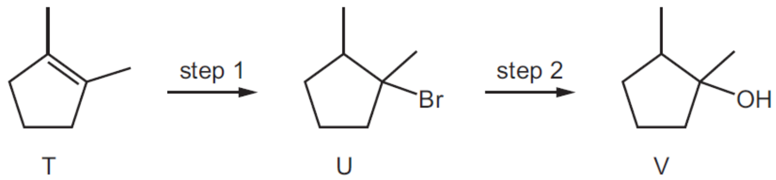
30. A student heats 1-bromopentane in aqueous potassium hydroxide. The product is further heated in acidified potassium permanganate. This product is then mixed with aqueous ammonia at room temperature. Which is the most likely final product?

A pentan-1-amine B pentanoic acid C 1,2-diaminopentane
D ammonium pentanoate E. 2-aminopentanoic acid

31. Which row correctly describes the reaction between propene and bromine, $Br_2(l)$?

	Type of reaction	Organic product
A	addition	$CH_3CHBrCH_2Br$
B	addition	$CH_3CH_2CH_2Br$
C	addition	$CH_3CHBrCH_3$
D	substitution	$CH_3CH_2CH_2Br$
E	substitution	$CH_3CHBrCH_2Br$

32. Hydrogen bromide can be added to T to give compound U. Compound U can be hydrolysed to compound V.



Five students, V, W, X, Y and Z, make the following statements.

V. Step 1 is an addition reaction

W. Step 1 is an elimination reaction

X. Step 2 is a substitution reaction

Y. All the atoms in a molecule of compound T lie in the same plane

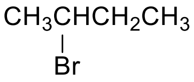
Z. Compound T has *cis-trans* isomers

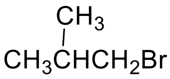
Which two students are correct?

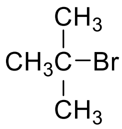
A. V and X B. V and Z C. X and Y D. X and Z E. Y and Z

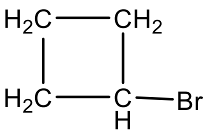
33. Structural isomerism and stereoisomerism should be considered in answering this question.
Compound J is reacted with KOH dissolved in ethanol. Three isomeric alkenes with molecular formula C_4H_8 are formed.
What is compound J?

A $CH_3CH_2CH_2CH_2Br$

B 

C 

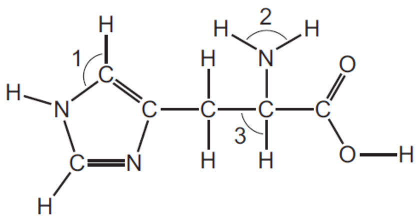
D 

E 

34. Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	Primary	Secondary	Tertiary
A	3	3	1
B	3	3	2
C	4	2	2
D	4	3	1
E	4	3	2

35. Histidine is an amino acid.



What are the approximate bond angles 1, 2 and 3?

	1	2	3
A	109.5	107	90
B	109.5	107	109.5
C	120	107	109.5
D	120	120	90
E	120	120	109.5

36. Which of the statements about the following two compounds is correct?

$CH_3CH_2CH(CH_3)CH_2CH_3$ $CH_3CH_2CH_2CH(CH_3)CH_3$

The two compounds are

A. Identical B. Structural isomers C. Geometric isomers D. *cis-trans* isomers E. Stereoisomers

37. Lewis dot structures can be used to determine whether a compound is polar due to having a molecular dipole. Which of the following compounds does NOT have a molecular dipole?

A. O_3 B. SeO_3 C. XeO_3 D. NH_3 E. PCl_3

38. Which ion has both more electrons than protons and more protons than neutrons?

[H = ${}^{1}_{1}H$; D = ${}^{2}_{1}H$; O = ${}^{16}_{8}O$]

A. H^+ B. D^- C. H_3O^+ D. OD^- E. OH^-

39. Which species has the smallest number of electrons?

A. B^{3+} B. Be^{2+} C. Li^+ D. H^- E. He^+

40. Which compound is non-polar (no net dipole moment) despite having polar covalent bonds?

A. CO_2 B. H_2O C. HCN D. N_2 E. NaCl