NZChO September exam 2021

1. The oxidation state of the iodine atom, I, in each of the following compounds is

   $H\underline{I}O_2$,　　$\underline{I}Cl$,　　$K\underline{I}O_3$

   A +3, +1, +5　　B +3, -1, +3　　C +5, -1, -3　　D +5, +1, +1　　E +5, -1, +3

2. For which conversion is an oxidising agent required?

   A. $Cl^-(aq) \longrightarrow OCl^-(aq)$

   B. $SO_3(g) \longrightarrow SO_4^{2-}(aq)$

   C. $2H^+(aq) \longrightarrow H_2(g)$

   D. $S_4O_6^{2-}(aq) \longrightarrow 2S_2O_3^{2-}(aq)$

   E. $N_2O_4(g) \longrightarrow 2NO_2(g)$

3. For the following reaction, which statement is **false**?

   $$3Cu(s) + 8HNO_3(aq) \rightarrow 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$$

   A. The solid copper has a formal oxidation state of zero

   B. The oxidation state of copper in $Cu(NO_3)_2$ is +2

   C. The nitrogen of NO_3^- is neither oxidized nor reduced in this reaction

   D. Both oxidation and reduction occur during this reaction

   E. H^+ is not reduced in this reaction

4. A reaction occurring in the extraction of lead from its ore can be represented by this unbalanced equation:

   __PbS+__O_2 →__PbO+__SO_2

   When the equation is balanced using the smallest possible whole numbers, what is the coefficient for O_2?

   A. 1　　B. 2　　C. 3　　D. 4　　E. 5

5. What is the OH^- concentration of a solution at pH 5.3?

   A. 6.31×10^{-5}　　B. 1.58×10^{-5}　　C. 6.31×10^{-10}　　D. 2.0×10^{-9}　　E. 1.58×10^{-10}

6. After mixing 30.0 mL of 0.20 mol L^{-1} $Ca(NO_3)_2$ solution and 15.0 mL of 0.50 mol L^{-1} NaCl solution, which ions are present in solution at concentrations of at least 0.15 mol L^{-1}?

   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

7. 10 mL of an HCl solution with a pH value of 2 was mixed with 90 mL of water. What will be the pH the resulting solution?

   A. 1　　B. 2　　C. 3　　D. 4　　E. 5

8. 0.1 mol L^{-1} aqueous solutions of these organic compounds were prepared. When these solutions are arranged in order of increasing pH (lowest pH first) what is the correct order?

I. $CH_3CH_2CH_2OH$

II. $CH_3CH_2CH_2NH_2$

III. CH_3CH_2COOH

A. I < II < III

B. I < III < II

C. III < II < I

D. II < III < I

E. III < I < II

9. Which aqueous solution contains the most H_3O^+ ions?

A. 20 mL of 2 mol L^{-1} sulfuric acid

B. 40 mL of 0.5 mol L^{-1} sulfuric acid

C. 10 mL of 4 mol L^{-1} nitric acid

D. 80 mL of 0.5 mol L^{-1} hydrochloric acid

E. 20 mL of 2 mol L^{-1} ethanoic acid, CH_3COOH

10. Equal volumes of 0.200 mol L^{-1} HCl and 0.400 mol L^{-1} KOH are mixed. The resulting concentrations are:

A. $[K^+]$ = 0.400 mol L^{-1}, $[Cl^-]$ = 0.200 mol L^{-1}, $[H_3O^+]$ = 0.200 mol L^{-1}

B. $[K^+]$ = 0.200 mol L^{-1}, $[Cl^-]$ = 0.100 mol L^{-1}, $[H_3O^+]$ = 0.100 mol L^{-1}

C. $[K^+]$ = 0.100 mol L^{-1}, $[Cl^-]$ = 0.100 mol L^{-1}, $[H_3O^+]$ = 0.100 mol L^{-1}

D. $[K^+]$ = 0.200 mol L^{-1}, $[Cl^-]$ = 0.100 mol L^{-1}, $[OH^-]$ = 0.100 mol L^{-1}

E. $[K^+]$ = 0.200 mol L^{-1}, $[Cl^-]$ = 0.200 mol L^{-1}

11. The following acids all play a role in human metabolism:

A. OHCCOOH (glyoxylic acid), M= 74.1 g mol^{-1}

B. $HOCH_2COOH$ (glycolic acid), M= 76.1 g mol^{-1}

C. $CH_3CH{=}CHCOOH$ (trans-2-butenoic acid), M = 86.1 g mol^{-1}

D. $CH_3CH(OH)COOH$ (lactic acid), M= 90.1 g mol^{-1}

E. $CH_3CH(OH)CH_2COOH$ (beta-hydroxybutyric acid), M= 104.1 g mol^{-1}

If titration of a solution containing a 0.200 g sample of one of the acids requires 23.25 mL of 0.1 mol L^{-1} NaOH solution to reach the endpoint, which one of the above compounds might it be? Assume that all the options will behave as monoprotic acids under these conditions.

12. Monocalcium phosphate ($CaHPO_4$) is used as an acid in baking powders. Solutions of $CaHPO_4$ in water may contain a variety of species. Which of the following is the conjugate base of the HPO_4^{2-} ion?

A. Ca^{2+} B. $OH^–$ C. H_2O D. $H_2PO_4^–$ E. $PO_4^{3–}$

Stoichiometry, Qualitative and Quantitative Analysis

13. Silver oxide (Ag_2O) decomposes to silver and oxygen upon heating. What amount of oxygen gas is produced when 4.64 g of silver oxide decomposes? $M(Ag_2O) = 232$ g mol^{-1}

A. 0.005 mol B. 0.01 mol C. 0.02 mol D. 0.04 mol E. 0.08 mol

14. Five beakers (labelled 1 to 5) each contain 0.5 moles of silver nitrate, dissolved in water. Into each of these beakers is added a certain amount of a metal chloride, also dissolved in water, as shown in the table below. Silver chloride precipitates from solution in all five beakers.

1	2	3	4	5
0.15 mol $CaCl_2$	0.20 mol $AlCl_3$	0.25 mol $CaCl_2$	0.30 mol NaCl	0.40 mol NaCl

Which two beakers contain the maximum mass of silver chloride precipitated?

A. 1 and 4 B. 2 and 3 C. 2 and 4 D. 3 and 5 E. 4 and 5

15. Plaster of Paris is used for setting broken limbs. Its formula is $CaSO_4{\cdot}0.5H_2O$ (M = 145.1 g mol^{-1}). When water is added it sets to give gypsum, $CaSO_4{\cdot}2H_2O$ (M = 172.2 g mol^{-1}). What is the minimum mass of water needed to set 0.500 kg of plaster of Paris?

A. 62.0 g B. 93.1 g C. 0.124 kg D. 2.90 kg E. 3.45 kg

16. Three substances R, S and T have the physical properties shown in the table below:

Substance	**R**	**S**	**T**
mp / °C	801	2852	3550
bp / °C	1413	3600	4827
Electrical conductivity of solid	Poor	Poor	Good

What could be the identities of R, S and T?

	R	**S**	**T**
A	MgO	NaCl	C(graphite)
B	MgO	NaCl	SiO_2
C	NaCl	MgO	Si
D	NaCl	MgO	C(graphite)
E	NaCl	MgO	SiO_2

17. A student had a bottle that contained either silver, magnesium, calcium, zinc or aluminium nitrate solution. A series of tests were carried out to determine what the cation is. The tests and observations are summarised below.

Test	Observation
Add 2 drops NaOH*(aq)*	• forms a precipitate
Add excess NaOH(*aq*)	• precipitate remains
Add HCl(*aq*) to a new sample	• forms a precipitate

The cation is

A. Ag^{+} B. Mg^{2+} C. Ca^{2+} D. Zn^{2+} E. Al^{3+}

18. $2AgNO_3\,(aq) + Zn(s) \rightarrow 2Ag(s) + Zn(NO_3)_2\,(aq)$

$Zn(NO_3)_2\,(aq) + Co(s) \rightarrow$ No reaction

$2AgNO_3\,(aq) + Co(s) \rightarrow Co(NO_3)_2\,(aq) + 2Ag(s)$

Using the above information, the order of increasing reactivity of the metals is

A. Ag<Zn<Co

B. Ag<Co<Zn

C. Co<Ag<Zn

D. Co<Zn<Ag

E. Zn<Co<Ag

19. $\mathbf{v}C_2H_3Cl(g) + \mathbf{w}O_2\,(g) \rightarrow \mathbf{x}CO_2\,(g) + \mathbf{y}H_2O(g) + \mathbf{z}HCl(g)$

Chloroethene can be burned in oxygen as shown above. What is the value of **w** when **v** = 2 ?

A. 2 B. 3 C. 4 D. 5 E. 6

20. The Born–Haber cycle for the formation of potassium chloride includes the steps below:

I. $K(g) \rightarrow K^{+}\,(g) + e^{-}$

II. $Cl_2(g) \rightarrow 2Cl(g)$

III. $Cl(g) + e^{-} \rightarrow Cl^{-}\,(g)$

IV. $K^{+}(g) + Cl^{-}(g) \rightarrow KCl(s)$

Which of these steps are exothermic?

A. I and II only B. III and IV only

C. I, II and III only D. I, III and IV only

E. IV only

21. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -197.8$ kJ

An increase in which of the following will increase the ratio of $SO_3(g)/SO_2(g)$ at equilibrium?

A. Pressure only

B. Temperature only

C. Both temperature and pressure

D. Neither pressure nor temperature

E. Addition of a catalyst

22. $2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

The equilibrium constant for the reaction above is 1.0×10^{-14} at 25 °C and 2.1×10^{-14} at 35 °C. What can be concluded from this information?

A. $[H_3O^+]$ decreases as the temperature is raised.

B. $[H_3O^+]$ is less than $[OH^-]$ at 35 °C.

C. $[H_3O^+]$ is greater than $[OH^-]$ at 35 °C.

D. Water is a stronger electrolyte at 25 °C.

E. The ionisation of water is endothermic.

23. The rate of a chemical reaction increases with increasing temperature. This increase in reaction rate is due to

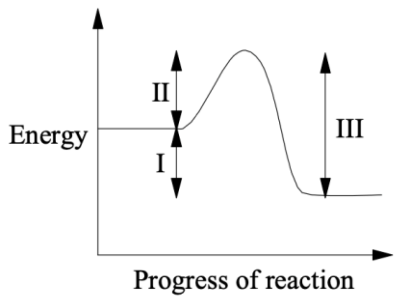
I. an increase in the collision rate.

II. a decrease in the activation energy.

III. an decrease in the number of molecules that react.

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

24.



Which energy value(s) will change when a catalyst is added?

A. I only

B. II only

C. I and II only

D. II and III only

E. I, II and III

25. Ethyne (HC≡CH) can add two molecules of hydrogen according to the equation

$$C_2H_2 + 2H_2 \rightarrow C_2H_6$$

Calculate the heat released (in kJ mol^{-1}) during this reaction, using the required bond energies from the following list:

C-H 413 C-C 347 C=C 614 C≡C 839 H-H 432

A. 1160 B. 788 C. 563 D. 521 E. 296

26. The gas NO_2 reacts to form a dimer N_2O_4 according to the equation

$$2NO(g) \rightarrow N_2O_4(g) \qquad \Delta H^o = -57.2 \text{ kJ mol}^{-1}$$

There will be more N_2O_4 present at equilibrium if:

A. the temperature is decreased or the volume is increased

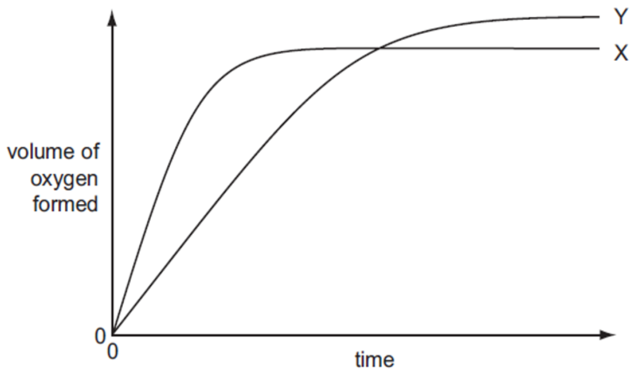
B. the temperature is decreased or the volume is decreased

C. the temperature is increased or the volume is increased

D. the temperature is increased or the volume is decreased

E. the temperature is increased and a catalyst is added

27. In the diagram below curve X was obtained by observing the decomposition of 100 mL of 1.0 mol L^{-1} hydrogen peroxide, catalysed by manganese dioxide, MnO_2.



Which alteration to the original experimental conditions would produce curve Y?

A. Adding some 0.1 mol L^{-1} hydrogen peroxide

B. Adding water

C. Lowering the temperature

D. Increasing the temperature

E. Using less manganese dioxide

28. The expression for the equilibrium constant for a reaction is

$$K_c = \frac{[B][C]}{[A]^2}$$

At a certain temperature the values of [A], [B] and [C] are all 0.2 mol L^{-1}. What happens to the value of K_c when all three values are doubled to 0.4 mol L^{-1}?

A. It decreases by a factor of four

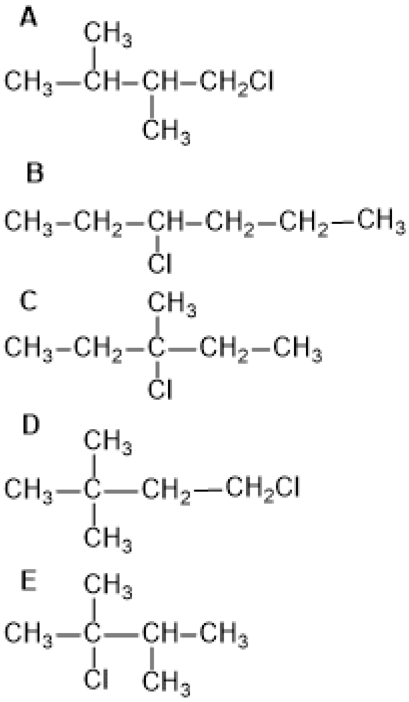
B. It is halved.

C. It does not change.

D. It doubles.

E. It increases by a factor of four

29. Which haloalkane below undergoes an elimination reaction to form the largest number of isomeric (structural and geometric) alkenes?



30. What is/are the product(s) of the reaction between ethene and hydrogen bromide?
   A. CH_3CH_2Br
   B. CH_3CH_2Br and H_2
   C. CH_2BrCH_2Br
   D. CH_2BrCH_2Br and H_2
   E. CH_3CHBr_2

31. How many different structural isomers have the formula C_4H_9Cl?

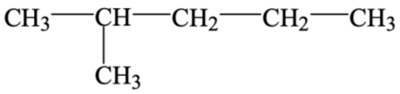
A. 2 B. 3 C. 4 D. 5 E. 6

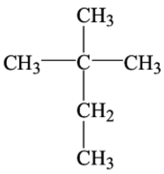
32. Which compound is formed by the dehydration of butan-2-ol, $CH_3CH(OH)CH_2CH_3$?
   A. $CH_3CH_2CH_2CHO$
   B. $CH_3COCH_2CH_3$
   C. $CH_3CCH_2CH_3$
   D. $CH_3CH{=}CHCH_3$
   E. $CH_3CH_2CH_2CH_3$

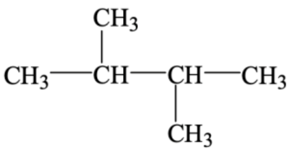
33. Which of the following answers identifies the correct type of reaction and reagent needed to convert butan-1-ol to butanoic acid.

	Type of reaction	**Reagent needed**
A	Oxidation	Conc H_2SO_4
B	Oxidation	$K_2Cr_2O_7/H^+$
C	Reduction	H_2/Pt
D	Substitution	$NaOH(aq)$
E	Substitution	$KMnO_4/H^+$

34. Which names are correct for the following isomers of C_6H_{14}?

I.  2-methylpentane

II.  2-ethyl-2-methylpropane

III.  2,3-dimethylbutane

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

35. Which of the following formulas could NOT be a compound with an alcohol functional group?

A. CH_4O B. C_2H_7N C. C_2H_7NO D. $C_2H_4O_3$ E. C_2H_6

36. Which of the following molecules has the largest bond angle?

A. H_2O B. CO_2 C. NH_3 D. BF_3 E. CF_4

37. What is the formula for the compound formed by barium and nitrogen?

A. BaN B. Ba_2N C. BaN_2 D. Ba_2N_3 E. Ba_3N_2

38. Which one of the following isotopes has 19 neutrons?

A. ^{19}F B. ^{35}Cl C. ^{35}S D. ^{37}Ca E. ^{39}K

39. In which of the following substances is the bonding the most ionic?

A. H_2 B. NaBr C. NBr_3 D. HBr E. Na

40. The table below shows the physical properties of five substances. Which substance could be ammonium chloride?

	Melting point/^oC	Electrical conductivity of solid	Electrical conductivity of aqueous solution	pH in solution
A	2000	poor	insoluble	Basic
B	-130	poor	good	Basic
C	-115	poor	good	Acidic
D	-50	poor	poor	Acidic
E	338	poor	good	Acidic