1. When alkene A is hydrogenated the alkane formed contains 83.33% C. What is the formula of the **alkene** A?

A. C_4H_8 B. C_4H_{10} C. C_5H_{10} D. C_5H_{12} E. C_6H_{12}

2. How many possible products, including all possible isomers formed, are produced when conc sulfuric acid is added to 3-methylhexan-3-ol.

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

3. A series of reactions are carried out to convert 2-chloropentane to pentanoic acid. Which of the following identifies the order in which the 3 types of reaction must be carried out?

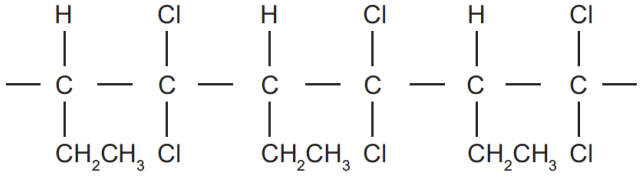
A. Substitution, elimination, addition
B. Elimination, addition, substitution
C. Substitution, addition, substitution
D. Elimination, substitution, oxidation
E. Elimination, addition, oxidation

4. Which formula is that of a secondary haloalkane?

A. $CH_3CH_2CH_2CH_2Br$ B. $CH_3CHBrCH_2CH_3$ C. $(CH_3)_2CHCH_2Br$

D. $(CH_3)_3CBr$ E. $(CH_3)_2CHCHBr_2$

5. The following structure shows a section of a polymer chain.



Which of the following is the correct name for the monomer used to make this polymer?

A. 1-chlorobutene B. 1,1-dichloro-but-1-ene C 4,4-dichlorobut-3-ne

D. 1,1-dichloro-2-ethylethene E. 1-ethyl-2,2-dichloroethene

6. Three organic liquids are in separate unlabelled bottles. Using only $Br_2(aq)$ which of the following are the 3 solutions that could be clearly identified?

A. ethanol, ethanoic acid, cyclohexene
B. ethanol, cyclohexane, cyclohexene
C. 2-chloro-2-methylbutane, cyclohexane, cyclohexene
D. 2-chloro-2-methylbutane, cyclohexane, ethanoic acid
E. ethanoic acid, propan-1-ol, cyclohexane

7. Which of the following formulae could NOT be that of an alcohol?

A. CH_4O B. $C_2H_6O_2$ C. C_2H_7NO D. C_2H_7N E. $C_2H_4O_3$

8. Nitrogen combines with bromine to form a molecule. Which of the following explains the shape of the molecule formed.
   A. Nitrogen forms three N-Br bonds that equally repel each other.
   B. There is a tetrahedral arrangement of bonding and non-bonding pairs of electrons around the central atom.
   C. The N-Br bond is polar.
   D. The N and Br atoms have a difference in electronegativity.
   E. The molecule formed obeys the octet rule.

9. In which of the following answers are all three molecules planar?

   A. H_2O, SO_3, NH_3 B. CO_2, NH_3, O_3 C. PCl_3, CH_4, CO_2

   D. SO_2, NH_3, CH_4 E. CO_2, BCl_3, SO_3

10. Which of the following molecules cannot have complete octets when drawn as a Lewis structure?

   A. CO_2 B. PO_2 C. S_8 D. SO_2 E. N_2O_3

11. Which statement relating to the elements in Group 17 and their compounds is correct?

   A. Bromine will reduce KI to form iodine.
   B. Chloride ions will oxidise bromine to form bromide ions
   C. Iodide ions react to form a white precipitate when added to silver nitrate solution.
   D. Bromide ions react to form a white precipitate when added to silver nitrate solution.
   E. Chlorine reacts with hydrogen to form a colourless gas.

12. The table below shows the number of protons, neutrons and electrons in five different particles V, W, X, Y and Z.

	Number of protons	Number of neutrons	Number of electrons
V	32	40	32
W	32	40	34
X	32	42	32
Y	34	40	32
Z	34	40	34

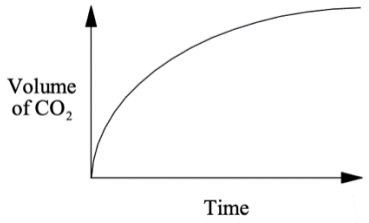
Which pair represents the atoms of two isotopes of the same element?

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

13. The carbon-carbon-carbon bond angle in CH_3CHCH_2 is closest to

   A. 180 B. 150 C. 120 D. 109 E. 90

14.



The curve above is obtained for the reaction of an excess of $CaCO_3$ with hydrochloric acid. How and why does the rate of reaction change with time?

Rate of reaction	**Reason**
A. decreases	the HCl becomes more dilute
B. decreases	the pieces of $CaCO_3$ become smaller
C. increases	the temperature increases
D. increases	the CO_2 produced acts as a catalyst
E. increases	more CO_2 is formed

15. The first step in nitric acid synthesis is the conversion of NH_3 to NO at about 900 ^oC.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta_r H = -907 \text{ kJ}$$

Which of the following would result in an increase in the yield of NO(g)

A. Using air rather than pure oxygen
B. Increasing the temperature at which the reaction is carried out
C. Removing the $H_2O(g)$ as it forms.
D. Decreasing the amount of $NH_3(g)$ added
E. Addition of a catalyst.

16. Before carrying out a titration between vinegar and NaOH(aq) the vinegar must be diluted so that 25.00 mL of the diluted vinegar will need between 12.00 mL and 25.00 mL of the NaOH to reach the equivalence point of the titration. To determine the dilution factor a rough titration was carried out. This showed that 1.0 mL of the vinegar needed 3.2 mL of the NaOH to reach equivalence point. Which of the dilution factors below would need to be used to ensure the titre value is in the required range.

A. 10.00 mL vinegar diluted to 100 mL
B. 10.00 mL vinegar diluted to 250 mL
C. 25.00 mL vinegar diluted to 100 mL
D. 25.00 mL vinegar diluted to 250 mL
E. 25.00 mL vinegar diluted to 500 mL

17. The manufacture of sulfur trioxide can be represented by the equation below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H^o = -197 \text{ kJ mol}^{-1}.$$

What happens when a catalyst is added to an equilibrium mixture from this reaction?

A. The yield of sulfur trioxide increases.
B. The rate of the forward reaction increases and that of the reverse reaction decreases.
C. The rates of both forward and reverse reactions increase.
D. The value of ΔH^o increases.
E. The value of ΔH^o decreases.

18. Hydrogen and carbon dioxide react as shown in the equation below.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

For this reaction the values of K_c with different temperatures are

Temperature/ ^{0}C	K_c
227	7.76×10^{-3}
427	1.23×10^{-1}
627	6.01×10^{-1}

Which statement for the reaction is correct?

A. $H_2O(g)$ and $CO(g)$ are more stable than $H_2(g)$ and $CO_2(g)$.
B. The reaction goes almost to completion at high temperatures.
C. The forward reaction is exothermic.
D. The forward reaction is endothermic.
E. The reverse reaction is favoured by high temperatures.

19. The equilibrium $2NO_2(g) \rightleftharpoons N_2O_4(g)$ is established at 25 ˚C in a glass piston.

The enthalpy change for the forward reaction is $\Delta_r H$ = -57.2 kJ mol^{-1}

Which of the following will result in an increased amount of N_2O_4?

A. A catalyst is added
B. An increase in temperature to 100 ^{o}C.
C. The piston is pushed in, halving the volume available to the gas
D. Removal of NO_2 from the system.
E. Argon gas is added to increase the total pressure.

20. Dodecane $C_{12}H_{26}$ is a fuel that undergoes complete combustion, the enthalpy change for this reaction being -8072 kJ mol^{-1}. The density of the fuel is 0.745 g mL^{-1}. What is the enthalpy change per litre (kJ L^{-1}) of dodecane fuel that undergoes complete combustion.

$M(C_{12}H_{26})$ = 170 g mol^{-1}

A. -35,374 B. -353.74 C. -35.374 D. -47.5 E. +35,374

21. Use the bond enthalpies provided to determine which of the answers below gives the enthalpy of the reaction in kJ mol^{-1}

$$H_2N\text{-}N{=}N\text{-}NH_2(g) \rightarrow H_2N\text{-}NH_2(g) + N{\equiv}N(g)$$

Bond	Bond enthalpy / kJ mol^{-1}
N-H	391
N-N	158
N=N	470
N≡ N	945

A. -475 B. -317 C. +317 D. +475 E. 633

22. For the reaction

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ the bond enthalpies (in kJ mol^{-1}) are

H-H	x
O=O	y
O-H	z

Which calculation will give the value, in kJ mol^{-1}, of ΔH^o for the reaction?

A. 2x+ y−2z B. 4z − 2x − y C. 2x + y − 4z
D. 2z − 2x − y E. 4x + y – 2z

23. The average bond enthalpy (or bond energy) of a C—F bond is 485 kJ mol^{-1}. In which of the following processes is the enthalpy change approximately equal to +1940 kJ mol^{-1}?

A. $CF_4(l) \rightarrow C(s) + 2F_2(g)$ B. $CF_4(g) \rightarrow C(s) + 2F_2(g)$
C. $CF_4(g) \rightarrow C(g) + 2F_2(g)$ D. $CF_4(g) \rightarrow C(s) + 4F(g)$
E. $CF_4(g) \rightarrow C(g) + 4F(g)$

24. Which of the following will be the same for separate 1 mol L^{-1} solutions of a strong acid and a weak acid?

I. Electrical conductivity
II. Concentration of H_3O^+ ions
III. pH

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

D. I, II and III E. None of I, II or III

25. When the pH of a solution changes from 2.0 to 4.0, the hydronium ion (H_3O^+) concentration

A. increases by a factor of 100
B. increases by a factor of 2
C. decreases by a factor of 2
D. decreases by a factor of 100
E. decreases by one half

26. What is the pH of a solution made by mixing 10.0 mL of 0.015 mol L^{-1} HCl and 25.0 mL of 0.025 mol L^{-1} HCl?

A. 1.12 B. 1.65 C. 1.75 D. 1.82 E. 2.00

27. The pH of the blood of a healthy person is in the range 7.35-7.45. What is the concentration (in mol L^{-1}) of OH^- in healthy blood at pH 7.35 and 37 ºC?
K_w at body temperature (37 ˚C) is 2.34×10^{-14} pK_w =13.63

A. 3.55×10^{-8} B. 4.47×10^{-8} C. 1.17×10^{-7}
D. 2.24×10^{-7} E. 5.25×10^{-7}

28. A 150 mL solution of 0.2 mol L^{-1} HCl was mixed with an unknown mass of NaOH, the final pH is 1.52. what is the mass of NaOH added?
M(NaOH= 40 g mol^{-1})

A. 0.2 g B. 0.5 g C. 1.0 g. D. 1.2 g. E. 1.5 g

29. Potassium hydrogen sulfide, KHS, is a slightly basic solution and will react with acid in the following equation:

$$HS^- + H_3O^+ \rightleftharpoons H_2S + H_2O$$

After HCl is added then a base (KOH) can be added to reform the HS^-, but when this is done the amount of KHS recovered is always lower than originally added. This is because:

A. HS^- is also an acid
B. HS^- is a weak base
C. H_2S is not very water soluble and some leaves the flask as a gas when acid is added.
D. Some H_2S forms an insoluble salt with HCl
E. HSCl forms a solid at the bottom of the flask.

30. In order to identify a white solid the following test were carried out.
Step 1 – When water was added to the sample the white solid dissolved to form a colourless solution.
Step 2 - To some of this solution acidified permanganate was added and a brown solution formed.
Step 3 -To another sample of the solution magnesium metal was added and a dark grey solid formed on the Mg strips; the strips themselves appeared to shrink and eventually disappeared leaving the newly formed dark grey solid.
Step 4 –When excess ammonia was added to a sample of solution a white solid formed and then disappeared when excess was added.

The solid was:
A. NaI B. AgCl C. $ZnSO_4$ D. ZnI_2 E. Na_2SO_4

31. Thiocyanate ions (SCN^-) react with iron(III) ions in solution to form a complex ion which is a blood-red colour.

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons [Fe(SCN)]^{2+}(aq)$$

In an experiment to find the equilibrium constant, *K*c, for this reaction 45.00 mL of a solution containing 0.200 mol L^{-1} of Fe^{3+} is mixed with 5.00 mL of a solution containing 0.00200 mol L^{-1} of SCN^-. The equilibrium concentration of $[Fe(SCN)]^{2+}$ in the mixture is found to be 1.99×10^{-4} mol L^{-1}.

Which of the following is the correct value of *K*c at the equilibration temperature?

A. 9.0×10^{-4} B. 5.0×10^{-1} C. 5.5×10^{-1} D. 5.5 E. 1.1×10^{3}

32. A 0.1 mol L^{-1} solution of potassium ethanoate, $KC_2H_3O_2$, has a lower pH than a 0.1 mol L^{-1} solution of potassium cyanide, KCN. From this, you can correctly conclude that

A. hydrocyanic acid, HCN, is a weaker acid than ethanoic acid, $HC_2H_3O_2$

B. hydrocyanic acid, HCN, is less soluble in water than ethanoic acid, $HC_2H_3O_2$

C. the cyanide ion, CN^-, is a weaker base than the ethanoate ion, $C_2H_3O_2^-$

D. cyanides are less soluble in water than ethanoates.

E. ethanoate ion, $C_2H_3O_2^-$, partially dissociates to form hydronium ion, H_3O^+.

33. In which reaction is water behaving as a Bronsted-Lowry base?

A. $H_2O + Na \rightarrow NaOH + \frac{1}{2} H_2$

B. $H_2O + H_3PO_4 \rightarrow H_3O^+ + H_2PO_4^-$

C. $H_2O + CaO \rightarrow Ca(OH)_2$

D. $NH_3 + [Cu(H_2O)_6]^{2+} \rightarrow NH_4^+ + [Cu(H_2O)_5(OH)]^+$

E. $H_2O + NH_3 \rightarrow NH_4^+ + OH^-$

34. For which conversion is an oxidant (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. $H_2O_2 \longrightarrow H_2O$

35. What are the oxidation states of chlorine in ClO_2, $HClO_3$ and $HClO_4$?

A. +1, +3, +5 B. +2, +5, +7 C. +2, +3, +6

D. +4, +5, +7 E. +4, +3, +5

36. What is the ratio of IO_3^- to N_2H_4 when the following oxidation-reduction equation is balanced?

$$IO_3^- + N_2H_4 \longrightarrow N_2 + I^- + H_2O$$

A. 1:1 B. 2:1 C. 1:2 D. 3:2 E. 2:3

37. A mining company carried out an analysis of an ore sample to find out how much copper was present. The analysis involved the steps shown below.

$2CuS + O_2 \rightarrow 2CuO + 2SO_2$ *Reaction 1*

$CuO + 2NH_4^+ \rightarrow Cu^{2+} + 2NH_3 + H_2O$ *Reaction 2*

$Cu^{2+} + 4NH_3 \rightarrow Cu(NH_3)_4^{2+}$ *Reaction 3*

Identify the row below that identifies the acid-base reaction and redox reaction.

	Acid-Base Reaction	**Redox Reaction**
A	Reaction 1	Reaction 2
B	Reaction 2	Reaction 3
C	Reaction 1	Reaction 3
D	Reaction 3	Reaction 1
E	Reaction 2	Reaction 1

38. Many people take zinc pills to boost their immune system. Zinc can, however, impair the absorption of other minerals, so copper is added to zinc pills in order to maintain a balance. If a pill contains 49.37 mg of $ZnSO_4$ (M= 161.4 g mol^{-1}), what mass of CuO (M = 79.5 g mol^{-1}), should be added to give a n(Zn) : n(Cu) ratio of 10:1?

A. 2.00 mg B. 2.43 mg C. 2.50 mg D. 4.94 mg E. 7.95 mg

39. What percentage of $Ca_5(PO_4)_3(OH)$ is calcium?

M(Ca) = 40.1 g mol^{-1} $M(Ca_5(PO_4)_3(OH))$ = 502 g mol^{-1}

A. 0.4 B. 0.8 C. 1.0 D. 8.0 E. 40

40. You have a solution which is 0.350 mol L^{-1} in $CaCl_2$. What volume of this solution would contain 0.070 moles of chloride ion?

A. 50 mL B. 100 mL C. 200 mL D. 400 mL E. 1000 mL