Anglo-Chinese School
(Independent)

YEAR 6

INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME

CHEMISTRY HIGHER LEVEL
PAPER 1

Monday **14 September 2020** **1 hour**

Additional materials:

Multiple choice answer sheet
Soft clean eraser
Soft pencil (type 2B recommended)

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Shade your Candidate number on the multiple choice answer sheet provided.

There are **forty** questions in this paper. Answer **all** the questions. For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the multiple choice answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet. A copy of the periodic table is provided for reference on Page 2 of the examination paper.
Calculators are **not** allowed to be used in this paper.

This question paper consists of 19 printed pages, including the cover page.

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01			Atomic number **Element** Relative atomic mass														2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Unt** (286)	114 **Uug** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. Which compound has the greatest percentage by mass of nitrogen atoms?

A. N_2H_4

B. NH_3

C. N_2O_4

D. $NaNO_3$

2. What is the sum of the coefficients when the equation is balanced?

$$\_\_\_\_\_\ C_6H_{14}\ (g) + \_\_\_\_O_2\ (g) \rightarrow \_\_\_\_CO\ (g) + \_\_\_\_H_2O\ (l)$$

A. 30

B. 39

C. 41

D. 54

3. What is the total number of electrons in all the s orbitals found in Cu^+?

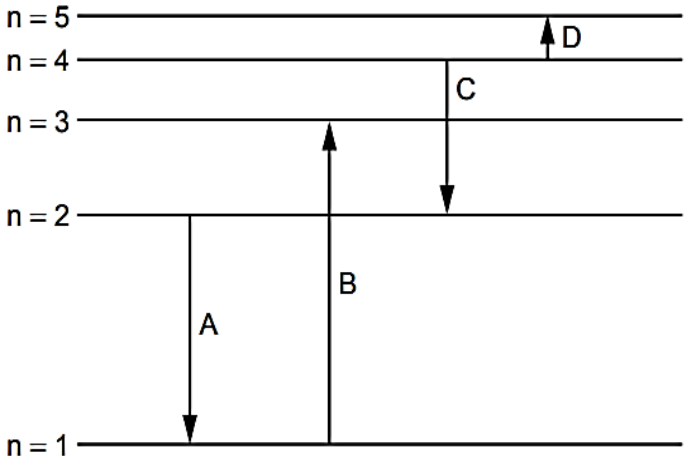
A. 0

B. 1

C. 5

D. 6

4. Which electron transition absorbs radiation with the shortest wavelength?



5. The first seven successive ionisation energies (in kJ mol^{-1}) of an atom of element **J** are given below:

1020 1950 2730 4580 6020 12300 15400

Which of the following statements about element **J** is correct?

A. It has a valence shell electronic configuration of $ns^2 np^4$.

B. Its atomic radius is larger than its ionic radius.

C. It forms a covalent chloride that has a trigonal pyramidal shape.

D. It forms an ionic compound with sodium in a 1:1 mole ratio.

6. Which compound has the shortest C to O bond?

A. CH_3CHO

B. CH_3COOH

C. CO_2

D. CO

7. Which species has a molecular geometry that is different from the CO_3^{2-} ion?

A. BF_3

B. PF_3

C. SO_3

D. NO_3^-

8. Which pair of molecules can form intermolecular hydrogen bonding with each other?

A. CH_4 and HF

B. CH_3OCH_3 and CF_4

C. CH_3OH and H_2O

D. CH_4 and H_2O

9. Which of the following information about the specified central atom is correct?

	Atom	**Number of electron domains about one central atom**	**Molecular geometry**	**Hybridisation**
A.	C in C_2F_2	2	linear	sp
B.	C in C_2H_6	4	square planar	sp^3
C.	N in NH_3	3	trigonal pyramidal	sp^3
D.	O in H_2O	4	bent	sp^2

10. Which species have resonance structures?

I. azide ion, N_3^-
II. carbon dioxide, CO_2
III. benzene, C_6H_6

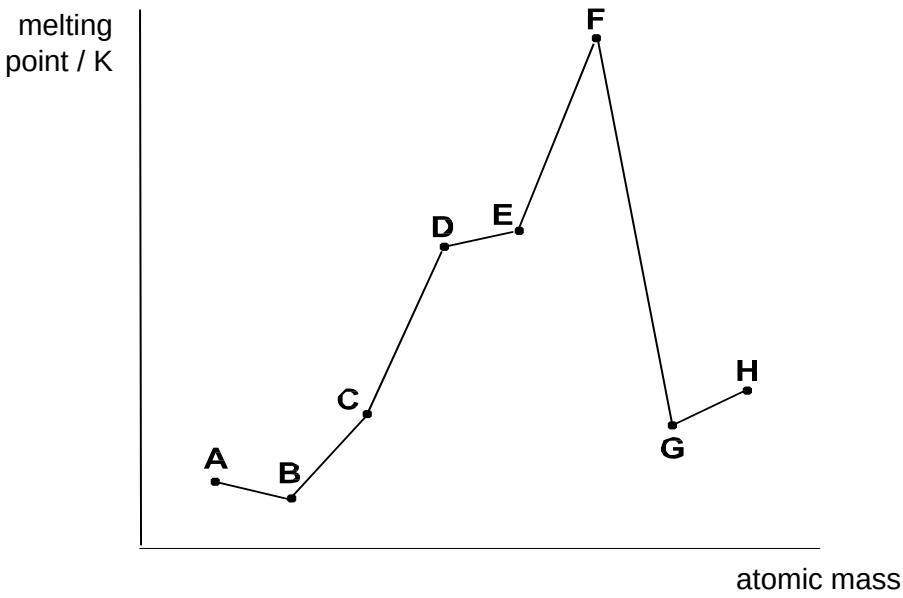
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. The graph below shows the variation in the melting points for the atoms of eight consecutive elements with atomic number below 20 in period 2 and 3 of the Periodic Table.



Which statement is correct?

A. Element **E** does not conduct electricity.

B. Element **D** forms an acidic oxide.

C. Element **H** forms covalent oxides with oxidation numbers of +4 and +6 respectively.

D. Element **C** is a gas which is chemically inert at room temperature.

12. Which pair of elements shows the greatest difference in electronegativity?

A. Na and S

B. Li and I

C. Mg and O

D. Cs and F

13. $EDTA^{4-}$ (aq) solution is added dropwise until in excess to a solution of $[CrCl_2(H_2O)_4]^+$. The equilibrium constant for this reaction is greater than 1 and the equation for the reaction is as shown below.

$$[CrCl_2(H_2O)_4]^+ (aq) + EDTA^{4-} (aq) \rightleftharpoons [Cr(EDTA)]^- (aq) + 2Cl^- (aq) + 4H_2O (l)$$

Which of the following statements about the above reaction is correct?

A. There is change in coordination number of the complex from 6 to 1.

B. $EDTA^{4-}$ is a weaker ligand than Cl^- ions.

C. Both $[CrCl_2(H_2O)_4]^+$ and $[Cr(EDTA)]^-$ are octahedral complexes.

D. It is a redox reaction.

14. Which equation correctly represents the standard enthalpy change of formation of a compound?

A. $2C (s) + 3H_2 (g) + \frac{1}{2} O_2 (g) \rightarrow C_2H_5OH (l)$

B. $2H_2 (g) + O_2 (g) \rightarrow 2H_2O (l)$

C. $Na (s) + Cl (g) \rightarrow NaCl (s)$

D. $C (g) + O_2 (g) \rightarrow CO_2 (g)$

15. Using the equations below:

$$C\,(s) + \frac{1}{2}\,O_2\,(g) \rightarrow CO\,(g) \qquad \Delta H_f = -110\ kJ$$
$$2Cr\,(s) + \frac{3}{2}\,O_2\,(g) \rightarrow Cr_2O_3\,(s) \qquad \Delta H_f = -1120\ kJ$$

what is the enthalpy change, ΔH (in kJ), for the following reaction?

$$Cr_2O_3\,(s) + 3C\,(s) \rightarrow 2Cr\,(s) + 3CO\,(g)$$

A. $-110 - 1120$

B. $-110 + 1120$

C. $3(-110) - 1120$

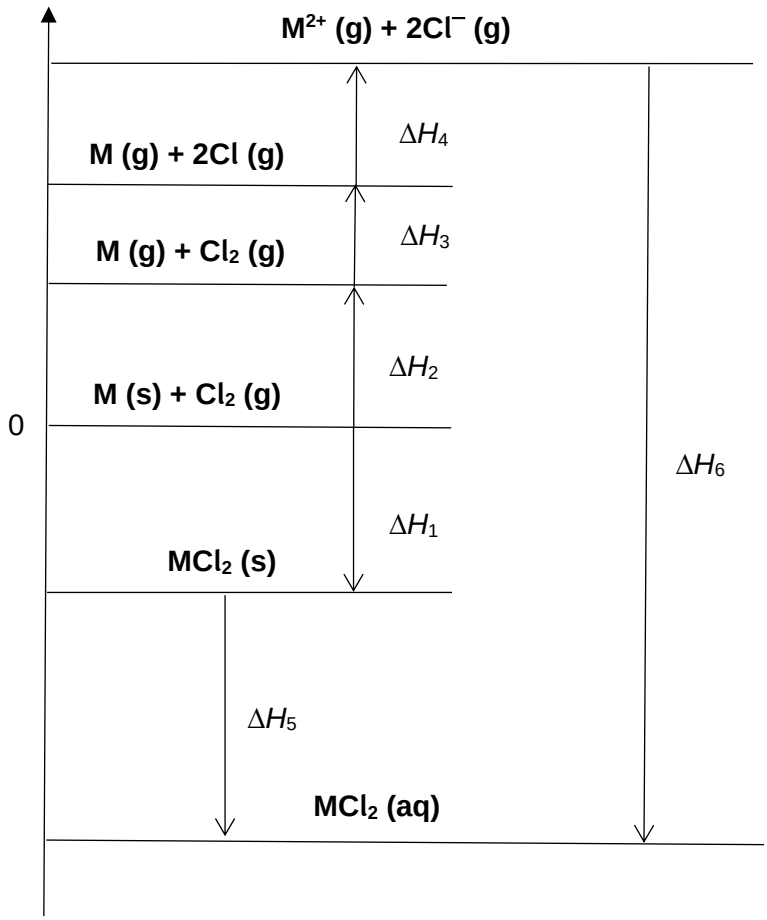
D. $3(-110) + 1120$

16. What are the correct signs for the enthalpy and entropy changes associated with the change below?

$$CO_2\,(s) \rightarrow CO_2\,(g)$$

	ΔH	ΔS
A.	+	−
B.	+	+
C.	−	−
D.	−	+

17. A Born-Haber cycle involving a metal chloride, MCl_2, is given below:



Which of the following correctly describes the energy changes?

	ΔH_2	ΔH_5	ΔH_6
A.	atomisation	hydration	solution
B.	bond enthalpy	hydration	lattice energy
C.	atomisation	solution	hydration
D.	bond enthalpy	solution	lattice energy

18. Which change does **not** increase the initial rate of reaction when $MgCO_3$ (s) is added to excess HCl (aq)?

$$MgCO_3\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$

A. A decrease in the size of the $MgCO_3$ (s) particles

B. An increase in the temperature of the reaction mixture

C. An increase in the concentration of HCl (aq)

D. Addition of deionised water into the reaction mixture

19. Which experimental methods could be used to observe the progress of the following reaction?

$$Cr_2O_7^{2-}\ (aq) + 6I^-\ (aq) + 14H^+\ (aq) \rightarrow 2Cr^{3+}\ (aq) + 3I_2\ (aq) + 7H_2O\ (l)$$

I. Change in colour
II. Change in mass
III. Change in electrical conductivity

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

20. The rate expression for the reaction **A** (g) + 2**B** (g) $\rightarrow$ 3**Z** (g) is

$$\text{rate} = k\,[\mathbf{A}]^0\,[\mathbf{B}]^2$$

By which factor will the rate of reaction increase when the concentrations of **A** and **B** are both increased by a factor of 3?

A. 3

B. 6

C. 9

D. 12

21. Which of the following statements of an Arrhenius plot of ln *k* against $\frac{1}{T}$ (K^{-1}) is correct?

$$\ln k = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln A$$

A. The graph has a positive gradient.

B. The activation energy can be calculated from the gradient.

C. The *y*–intercept is the frequency factor, A.

D. The gradient becomes steeper when a catalyst is added.

22. Solid iodine and its vapour are at equilibrium inside a sealed container.

$$I_2\,(s) \rightleftharpoons I_2\,(g)$$

Which change will shift the position of equilibrium to the right?

A. Decreasing the mass of solid iodine

B. Increasing the mass of solid iodine

C. Increasing the volume of the container

D. Decreasing the temperature of the mixture

23. When 0.2 mol dm^{-3} of propanone reacts with 0.3 mol dm^{-3} of methanol, 0.04 mol dm^{-3} of acetal was formed at equilibrium at 298 K. The chemical equation is given below:

$$CH_3COCH_3\ (l) + 2CH_3OH\ (l) \rightleftharpoons \underset{\text{acetal}}{CH_3C(OCH_3)_2CH_3}\ (l) + H_2O\ (l)$$

What is the value of the equilibrium constant of the reaction at 298 K?

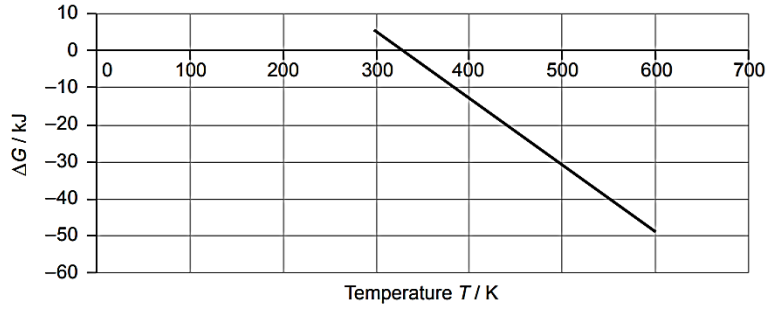
A. $\dfrac{(0.04)}{(0.2)(0.3)}$

B. $\dfrac{(0.04)^2}{(0.2)(0.3)^2}$

C. $\dfrac{(0.04)}{(0.16)(0.22)^2}$

D. $\dfrac{(0.04)^2}{(0.16)(0.22)^2}$

24. The graph shows values of ΔG for a reversible reaction at different temperatures.



Given that,

$$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$$

which of the following statements is **incorrect**?

A. The standard entropy change of the reaction is positive.

B. The forward reaction is endothermic.

C. The K_c remains constant with increasing temperature.

D. The position of equilibrium lies towards the product as temperature increases.

25. Which ions produced by the dissociations of phosphoric acid, H_3PO_4, are amphiprotic?

A. HPO_4^{2-} and PO_4^{3-}

B. $H_2PO_4^-$ and HPO_4^{2-}

C. $H_2PO_4^-$ and PO_4^{3-}

D. HPO_4^{2-} only

26. Which is a conjugate acid-base pair according to the Brønsted–Lowry theory?

$$CH_3COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3COO^-\ (aq) + H_3O^+\ (aq)$$

A. H_2O / H_3O^+

B. H_2O / CH_3COO^-

C. CH_3COO^- / H_3O^+

D. CH_3COOH / H_2O

27. Which of the following 1.0 mol dm^{-3} solutions, when mixed, produces an acidic buffer?

A. 50 cm^3 HCl (aq) and 150 cm^3 NH_3 (aq)

B. 100 cm^3 CH_3COOH (aq) and 50 cm^3 HCl (aq)

C. 100 cm^3 CH_3COOH (aq) and 50 cm^3 NaOH (aq)

D. 50 cm^3 CH_3COOH (aq) and 50 cm^3 NaOH (aq)

28. The acid–base indicator phenol red, HIn, changes colour from yellow to red over a pH range of 6.6 – 8.2.

$$HIn\ (aq) \rightleftharpoons H^+\ (aq) + In^-\ (aq)$$

Which statement is correct?

A. In a strongly acidic solution, [HIn] < [In^-].

B. The pK_a of phenol red is between 6.6 and 8.2.

C. The In^- ions are yellow.

D. Phenol red would be a suitable indicator for the titration of a strong acid and a weak base.

29. In an aqueous solution, HIO disproportionates according to the following equation.

$$\boldsymbol{a}HIO \rightarrow \boldsymbol{b}I_2 + \boldsymbol{c}HIO_3 + \boldsymbol{d}H_2O$$

What are the correct values of ***a***, ***b***, ***c*** and ***d***?

	a	***b***	***c***	***d***
A.	4	1	2	2
B.	5	2	2	1
C.	4	1	1	1
D.	5	2	1	2

30. The table below contains the standard reduction potential values for some cobalt and mercury species.

half-equation	$E^{\ominus}$ **/ V**
$Co^{3+}(aq) + e^- \rightleftharpoons Co^{2+}(aq)$	+1.82
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	−0.28
$Hg^{2+}(aq) + e^- \rightleftharpoons Hg^{+}(aq)$	+0.91
$Hg^{+}(aq) + e^- \rightleftharpoons Hg(l)$	+0.80

Which of the following predictions is correct about the disproportionation of Co^{2+} and Hg^{+}?

A. Both Co^{2+} and Hg^{+} will undergo disproportionation reaction.

B. Neither Co^{2+} nor Hg^{+} will undergo disproportionation reaction.

C. Only Co^{2+} will undergo disproportionation reaction.

D. Only Hg^{+} will undergo disproportionation reaction.

31. Chlorine reacts with hot concentrated sodium hydroxide according to the equation below.

$$3Cl_2(g) + 6NaOH(aq) \rightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$$

Which statement about the above reaction is correct?

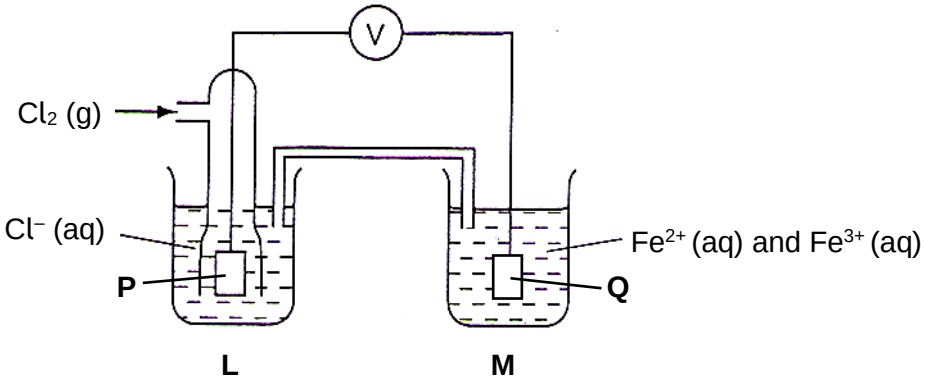
A. Chlorine is simultaneously oxidised and reduced.

B. Sodium hydroxide acts as an oxidising agent.

C. The oxidation number of oxygen increases from −2 to 0.

D. The oxidation number of the chlorine in both products is −1.

32. The cell shown below is set up under standard conditions where **P** and **Q** are platinum electrodes.



Given the following electrode potentials,

$E^{\ominus}(Fe^{3+}/Fe^{2+}) = +0.77$ V
$E^{\ominus}(Cl_2/Cl^-) = +1.36$ V

which of the following statements is correct?

A. **P** is the anode.

B. The voltmeter will show a reading of about 2.13 V.

C. The electrons will flow from **Q** to **P** through the voltmeter.

D. The concentration of the electrolyte used in half cell **M** is 0.5 mol dm^{-3} of Fe^{2+} (aq) and Fe^{3+} (aq).

33. Study the reaction scheme below. What could compound **X** be?

$$CH_3CH_2Br \rightarrow \mathbf{X}$$
$$\mathbf{X} \rightarrow CH_3COOH$$

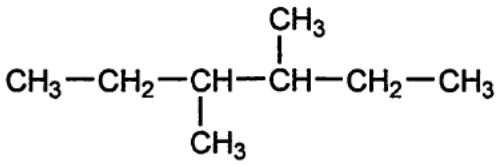
A. CH_3CHO

B. CH_3OCH_3

C. CH_3CH_2OH

D. $H_2C{=}CHBr$

34. What is the name of this compound using the IUPAC rules?



A. 2,3-diethylbutane

B. 2-ethyl-3-methylpentane

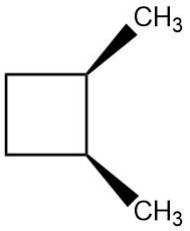
C. 3-methyl-4-ethylpentane

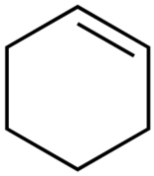
D. 3,4-dimethylhexane

35. Which compound can exist as *cis*- and *trans*-isomers?

A. $CBr_2=CF_2$

B. $CH_2=CHCH_2Br$

C. 

D. 

36. Which is the major product of the electrophilic addition of hydrogen bromide to propene?

A. $BrCH_2CH=CH_2$

B. $CH_3CH(Br)CH_3$

C. $CH_3CH_2CH_2Br$

D. $CH_3CH=CHBr$

37. The enthalpy change in a neutralisation reaction can be determined by mixing equal volumes of H_2SO_4 (aq) and NaOH (aq) of the same concentration in a glass beaker. The experiment was repeated 5 times and all measurements obtained were 5 ^oC higher than the true value.

Which statement is correct about the precision and accuracy of the measurements?

A. Precise and accurate

B. Precise but inaccurate

C. Accurate but not precise

D. Neither accurate nor precise

38. Which of these pairs of compounds have the same degree of unsaturation or index of hydrogen deficiency (IHD)?

A. C_4H_6 and C_3H_5NO

B. C_5H_6O and $C_5H_{10}O_2$

C. C_5H_6O and C_3H_5NO

D. C_4H_6 and $C_5H_{10}O_2$

39. Compound **Y** is a hydrocarbon. Its ^1H NMR spectrum shows a singlet signal only.

Which of the following can compound **Y** be?

I. 2,2–dimethylpropane
II. ethane
III. but–2–ene

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. Which of the following compounds exhibit three signals with an integration trace of 1 : 2 : 3 in the ^{1}H NMR spectrum?

I. CH_2CHCH_3
II. $CH_3CH(OH)CH_3$
III. $CH_3CHBrCH_2Cl$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

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