

2021 JUNIOR CANADIAN CHEMISTRY OLYMPIAD

The Periodic Table/Data Sheet may be used for all parts of the contest, and non-programmable calculators are allowed.

考试期间允许使用化学元素周期表、数据表以及非编程计算器。

Write your answers on the Scantron Sheet provided using a 2B pencil. 请将答案用 2B 铅笔正确填涂在答题卡上。

Students are expected to attempt all questions for a complete examination in 1.5 hours. 考试时长为 1.5 小时。

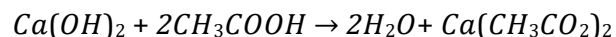
- 1) The highest-grade uranium deposits in the world are found in the Athabasca Basin in Canada with an average of 18% by weight uranium. If a mine in the Athabasca Basin collects 1 metric ton (1000 kg) of ore, how many moles of uranium can be extracted from the ore?

世界上最富的铀矿床位于加拿大的阿萨巴斯卡盆地，铀的平均储量为 18%。如果阿萨巴斯卡盆地的一个矿区收集 1 公吨（1000 公斤）的矿石，能从这些矿石中提取多少摩尔的铀？

A) 4200 B) 420 C) 756 D) 7560 E) 4.20

- 2) Several general types of chemical reactions can occur based on what happens when going from reactants to products. What is the type of the following reaction?

根据从反应物到生成物所发生的变化，可以将化学反应分成几种基本类型。下列属于哪种反应类型？



- A) Synthesis 化合反应
B) Single replacement 置换反应
C) Decomposition 分解反应
D) Neutralization 中和反应
E) Combustion 氧化反应

- 3) Calculate the mass of potassium iodide (KI) required to prepare a 0.30 M solution in water using a 250 mL volumetric flask?

使用 250 mL 的容量瓶配制 0.30 M 的 KI 水溶液，计算需要碘化钾 (KI) 的质量是多少？

A) 5.98 g B) 199.2 g C) 12.45 g D) 49.80 g E) 24.90 g

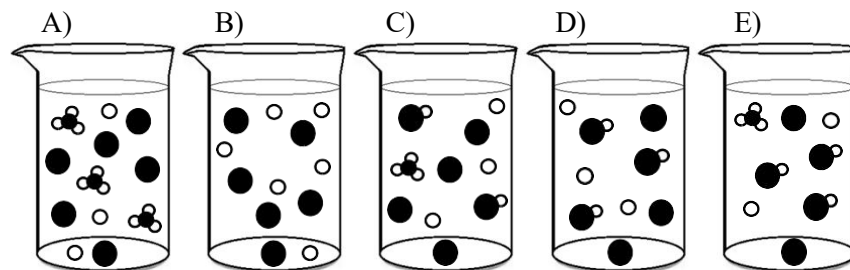
- 4) Which of the following chemical equations is properly balanced?
以下化学方程式配平正确的是哪个？

- A) $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$
B) $\text{C}_6\text{H}_8 + 6\text{O}_2 \rightarrow 5\text{CO}_2 + 4\text{H}_2\text{O}$
C) $\text{CH}_3\text{CH}_2\text{OH} + 3\text{O}_2 \rightarrow \text{CO}_2 + 3\text{H}_2\text{O}$
D) $\text{CH}_3\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
E) $2\text{C}_7\text{H}_5\text{N}_3\text{O}_6 \rightarrow 3\text{N}_2 + 5\text{H}_2 + 12\text{CO} + 2\text{C}$

- 5) A 250 mL beaker is filled with 100 mL of a 0.30 M solution of acetic acid (CH_3COOH) and 150 mL of a 0.10 M solution of sodium hydroxide. Acetic acid is a weak acid and all solutions have been prepared in water. Which beaker diagram is the best representation of the solution obtained after the reaction is complete?

一个 250 mL 的烧杯中装有 100 mL 0.30 M 的醋酸 (CH_3COOH) 溶液和 150 mL 0.10 M 的氢氧化钠溶液。醋酸是一种弱酸，所有的溶液溶剂都是水。以下哪个烧杯图可以表示反应完成后得到的溶液？

Legend: Na^+ ○ CH_3COO^- ●
图解 H_3O^+ ○●● CH_3COOH ○●●



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- 6) The density of chloroform (CHCl_3) at 25°C is 1.4788 g/cm^3 . What is the volume of 1 mole of chloroform at 25°C ?

氯仿 (CHCl_3) 在 25°C 下的密度是 1.4788 g/cm^3 , 请问在 25°C 下 1 mol 氯仿的体积是多少?

A) 34.1 mL B) 80.7 mL C) 176.5 mL D) 17.7 mL E) 56.7 mL

- 7) The province of Saskatchewan is one of the world's biggest producer of potash (a source of potassium used as soil fertilizer). Potash amounts are reported in K_2O equivalent, although it never contains potassium oxide. The K_2O equivalent system is used to compare weights of fertilizers because it is only the potassium weight that matters, the weight of the anion is irrelevant. If 200 tons of K_2CO_3 were extracted from a mine, what would be the K_2O equivalent weight in tons?

萨斯喀彻温省是世界上最大的钾肥 (钾的一种来源, 用作土壤肥料) 生产地之一。虽然钾肥不含氧化钾, 但其含量还会按照 K_2O 来计算, K_2O 当量体系用于比较肥料的重量, 其中只考虑钾元素的重量, 不考虑阴离子的重量。如果从矿井中提取出 200 吨 K_2CO_3 , 等效于 K_2O 的质量是多少吨?

A) 113.2 B) 293.4 C) 136.3 D) 353.5 E) 56.6

- 8) Octane rating is used as a standard measure of the performance of a car engine. The octane isomer 2,2,4-trimethylpentane (C_8H_{18}) is the 100% reference standard for octane rating and has a density of 0.690 g/cm^3 . If 1 litre of 2,2,4-trimethylpentane is burned in excess of oxygen (O_2) how many grams of CO_2 is produced?

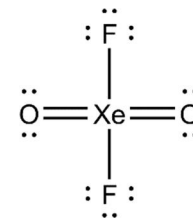
辛烷值是衡量汽车发动机性能的标准。辛烷异构体 2,2,4 - 三甲基戊烷 (C_8H_{18}) 是辛烷值为 100% 的参考标准, 其密度为 0.690 g/cm^3 。如果 1 升 2,2,4 - 三甲基戊烷在过量的氧气 (O_2) 中燃烧, 会产生多少克 CO_2 ?

A) 352.1 B) 913.8 C) 5520 D) 2127 E) 1791

- 9) The Lewis structure of XeO_2F_2 shown below is not the best. Explain by selecting the best answer from the list.

如图所示的 XeO_2F_2 的路易斯结构并不是最佳的。

以下哪项是最好的解释?



- A) The total number of electrons is incorrect
电子总数不正确
- B) The central atom cannot be hypervalent
中心原子不能是高价态
- C) A terminal atom is hypervalent
末端一个原子是高价态
- D) The formal charges are calculated correctly but not minimized
形式电荷数计算正确, 但并非最小数量。
- E) Noble gas never make compounds
惰性气体不可能合成化合物

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- 10) Effective nuclear charge (Z_{eff}) is a useful tool for understanding periodicity. Z_{eff} is the net positive charge experienced by an electron in a polyelectronic atom. The term "effective" is used because the positive charge of the nuclei cannot reach a given electron completely, due to the shielding effect of other electrons. Z_{eff} is a theoretically calculated value (not an atomic property) but a good estimate of Z_{eff} can be obtained using Slater's rule. Slater's rule states that $Z_{\text{eff}} = Z - S$ where Z is the atomic number of the atom and S a screening constant. In the second row of the periodic table, the screening value is 0.85 for a core electron and 0.35 for a valence electron. The screening constant (S) is obtained by the summation of all the screening values of other electrons (excluding the electron for which the effective nuclear charge is to be determined). Use Slater's rule to estimate the effective nuclear charge for a valence electron in fluorine (F).

有效核电荷 (Z_{eff}) 是了解周期性的有用工具。 Z_{eff} 是多电子原子中电子受到原子核吸引的净正电荷数。使用“有效”一词是因为原子核的正电荷由于其他电子的屏蔽作用而不能完全到达给定的电子。 Z_{eff} 是一个理论值 (不属于原子性质), 但是使用斯莱特法则可以很好地估计 Z_{eff} 。斯莱特法则指出 $Z_{\text{eff}} = Z - S$, 其中 Z 是原子的原子序数, S 是屏蔽常数。在元素周期表第二行中, 一个核心电子的屏蔽值为 0.85, 一个价电子的屏蔽值为 0.35。屏蔽常数 (S) 是将其他电子 (不包括要测定有效核电荷的电子) 的屏蔽值相加得到的。利用斯莱特法则估算氟 (F) 中价电子的有效核电荷。

A) 4.85 B) 5.20 C) 4.15 D) 3.80 E) 8.65

- 11) To study weather phenomena one uses sensors carried by balloons. On a beautiful summer day when the temperature on the ground is 25°C and the pressure is 101.325 kPa, a balloon is partially inflated with 70 m^3 of helium. The balloon is released and climbs to an altitude of 10 kilometers. Calculate the volume of the balloon if the temperature has dropped to -50.0°C and the pressure to 27.5 kPa. Assume ideal gas behavior.

可以用装有传感器的气球来研究天气现象。在一个美丽的夏日, 地面温度为 25°C , 气压为 101.325 kPa, 将 70 m^3 的氦气充入气球, 释放气球后上升至 10 公里的高度。如果气温下降到 -50.0°C , 气压下降到 27.5 kPa, 在理想气体状态下, 计算此时气球的体积。

A) 193.0 m^3 B) 93.4 m^3 C) 52.4 m^3 D) 25.4 m^3 E) 257.9 m^3

- 12) What is the molecular geometry of NH_3 ?
 NH_3 分子的空间构型是什么?

A) Trigonal Planar 平面三角形
 B) Trigonal Bipyramidal 三角双锥形
 C) Square Pyramidal 四角锥形
 D) Trigonal pyramidal 三角锥形
 E) Tetrahedral 四面体

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- 13) Which of the following element is expected to be the most electronegative?

以下哪个元素的电负性最大?

A) Lu B) Ts C) Ra D) Lr E) U

- 14) Electroplating has many useful applications. It can improve a metal's surface appearance, electrical conductivity or anti-corrosion properties. 49.2 g of a copper salt is dissolved in 250 mL of water and the solution is used for electroplating until all the copper is reduced. After the experiment it is found that the cathode weight as increased by exactly 14.0 g. What is the chemical formula of the copper salt used?

电镀有很多广泛应用，它可以改善金属外观，提高导电性及防腐性能。将 49.2 g 的铜盐溶解在 250 mL 的水中，溶液可以用于电镀，直到所有的铜都被还原。实验结束后发现，阴极的重量增加了 14.0 g，请问用到的铜盐的化学式是什么？

A) CuCl_2 B) CuSO_4 C) CuSO_3 D) CuBr_2 E) $\text{Cu}(\text{NO}_3)_2$

- 15) Which of the following molecules can form a hydrogen bond?

以下哪种分子可以形成氢键？

A) HBr B) HF C) CH_4 D) H_2CO E) CF_3H

- 16) After the earthquake and tsunami disaster, the soil, the air, and the water near the Fukushima Daiichi Nuclear Power Plant in Japan were found to be contaminated with radioactive ^{137}Cs , which has a half-life of 30.1 years. Radioactive decay is a first order process. How many years must pass before the radioactivity drops to 12.5% of its initial value?

地震和海啸灾难发生后，日本福岛第一核电厂附近的土壤、空气和水都受到放射性物质 ^{137}Cs 的污染，它的半衰期是 30.1 年。放射性衰变过程是一级反应，需要多少年才能使放射性下降到初始值的 12.5%？

A) 240.8 B) 376.3 C) 60.2 D) 120.4 E) 90.3

- 17) Sodium benzoate is produced by the neutralization of benzoic acid and is commonly used as a pH adjustor and preservative in food. Benzoic acid has a pK_a of 4.2 and is an aromatic carboxylic acid. What is the pH of a 0.10 M solution of benzoic acid?

苯甲酸钠是通过中和苯甲酸生产的，常用作食物的 pH 调节剂和防腐剂。苯甲酸的 pK_a 为 4.2，是一种芳香羧酸。

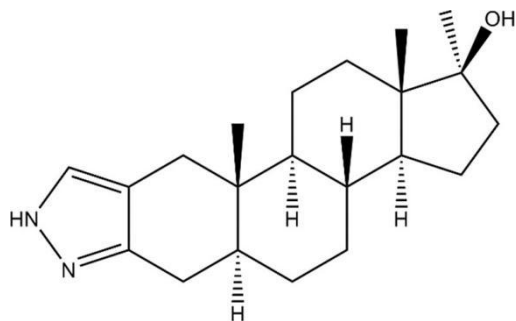
请问 0.10 M 苯甲酸溶液的 pH 值是多少？

A) 2.6 B) 3.1 C) 3.6 D) 5.2 E) 1.0

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- 18) Most serious athletes will tell you that the drive to win is fierce. Besides the satisfaction of personal accomplishment, Olympic athletes often pursue dreams of winning a medal for their country. In such an environment, the use of anabolic steroids has become increasingly common. Anabolic steroids are synthetic variations of the male hormone testosterone. Which of the following molecular formula is the correct one for the steroid shown below?

大多数认真的运动员都会告诉你，获胜的动力是极其强烈的。除了实现个人成就感，奥林匹克运动员经常梦想为自己的国家赢得奖牌。这种环境下，使用合成代谢类固醇变得越来越普遍。合成代谢类固醇是雄性激素睾酮的合成变体，下图所示的类固醇的分子式是哪个？



- A) $C_{20}H_{26}N_2O$
 B) $C_{18}H_{32}N_2O$
 C) $C_{21}H_{28}N_2O$
 D) $C_{21}H_{32}N_2O$
 E) $C_{18}H_{26}N_2O$

- 19) An unknown liquid organic compound contains carbon, hydrogen and oxygen only. It has a very high normal boiling point of 205.8°C . 1.00 gram of this compound undergoes complete combustion reaction to produce 2.27g of carbon dioxide and 0.931g of water. When this compound is vaporized at its normal boiling point, the gaseous phase has a density of 2.96 g/L. Based on the information given, this compound is

一种未知的液态有机化合物，只含有碳、氢和氧三种元素，它的标准沸点高达 205.8°C 。1.00g 这种化合物经过完全燃烧反应可以生成 2.27g 二氧化碳和 0.931g 水。当这种化合物在标准沸点下蒸发时，气态的密度为 2.96 g/L。根据给出的信息推断，这个化合物是

- A) Acetone 丙酮
 B) Propanal 丙醛
 C) Cyclopropanol 环丙醇
 D) Hexanoic acid 己酸
 E) Ethyl Butanoate 丁酸乙酯

- 20) Which of the following atoms or ions has the largest radius?

以下哪个原子/离子的半径最大？

- A) Fr^+ B) Br^- C) Og D) Kr E) At^-

- 21) How much energy is needed to convert 50.0 grams of ice from -10°C to a steam of 110°C . The specific heat is 2.108J/g for ice, 4.184J/g for water and 1.996J/g for steam. The heat of fusion is 6.02kJ/mol for ice and heat of vaporization is 40.7kJ/mol for water.

50.0 g 的冰从 -10°C 转化成 110°C 的水蒸气需要多少能量？冰的比热容是 2.108J/g ，水的比热容是 4.184J/g ，水蒸气的比热容是 1.996J/g ，冰的熔化热为 6.02kJ/mol ，水的蒸发热为 40.7kJ/mol 。

- A) 152.6kJ B) 1526J C) 2359J D) 235.9kJ E) 23.59kJ

- 22) When the intermolecular force of a liquid increases, which of the following statement is incorrect?

当液体的分子间作用力增大时，下列哪一项陈述是不正确的？

- A) Boiling point increases 沸点升高
 B) Viscosity increases 粘度变大
 C) Surface tension increases 表面张力增大
 D) Vapour pressure increase 蒸气压增大
 E) Density increases 密度变大

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23) Which of the following listed particles are isoelectronic?

哪个选项中的微粒属于等电子体?

- A) C, N, O, F, Ne
- B) B, Si, As, Te, At
- C) Mg^{2+} , Na^+ , Ne, F^- , O^{2-}
- D) C, Si, Ge, Sn, Pb
- E) Mn, Fe, Co, Ni, Cu

24) Diethyl ether and butanol are two organic isomers. What do they have in common under the same temperature and pressure?

二乙醚和丁醇互为同分异构体。在相同温度和压力下，它们有什么共同点?

- A) Solubility in water 水溶性相同
- B) Heat of vaporization 蒸发热相同
- C) Molar volume 摩尔体积相同
- D) Reactivity 活动性相同
- E) Gaseous state density 气态密度相同

25) A hydrocarbon mixture known to contain methane, ethene and butane only has a volume of 6.00L, a pressure of 2 bar and density of $2.404 \times 10^{-3} \text{ g/mL}$ at 25°C . When this mixture reacted with hydrogen gas in the presence of platinum metal, 0.3145 g of hydrogen gas was consumed. When the same amount of the mixture was completely combusted, 43.13g of carbon dioxide and 23.69g of water were produced. What was the mass percentage of methane in the mixture? (assume all reactions went to completion).

一种碳氢化合物的混合物由甲烷、乙烯和丁烷组成，温度为 25°C 时，体积只有 6.00 L，压强为 2 bar，密度为 $2.404 \times 10^{-3} \text{ g/mL}$ 。当这种混合物在铂金属存在的条件下与氢气反应，会消耗 0.3145g 氢气，等量的混合物完全燃烧后，会产生 43.13g 二氧化碳和 23.69g 水。请问混合物中甲烷的质量百分比是多少? (假设每步反应都完全)

- A) 19 % B) 24 % C) 30 % D) 45 % E) 50 %

End of examination questions.

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Periodic table and data sheet

JUNIOR CANADIAN CHEMISTRY OLYMPIAD																		2							
1	Periodic table and data sheet																He 4.003 Helium								
3		4																5		6	7	8	9	10	
Li 6.941 Lithium		Be 9.012 Beryllium																B 10.81 Boron		C 12.01 Carbon	N 14.01 Nitrogen	O 16.00 Oxygen	F 19.00 Fluorine	Ne 20.18 Neon	
11		12																13		14	15	16	17	18	
Na 22.99 Sodium		Mg 24.31 Magnesium																Al 26.98 Aluminium		Si 28.09 Silicon	P 30.97 Phosphorus	S 32.07 Sulfur	Cl 35.45 Chlorine	Ar 39.95 Argon	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36								
K 39.10 Potassium	Ca 40.08 Calcium	Sc 44.96 Scandium	Ti 47.87 Titanium	V 50.94 Vanadium	Cr 52.00 Chromium	Mn 54.94 Manganese	Fe 55.85 Iron	Co 58.93 Cobalt	Ni 58.69 Nickel	Cu 63.55 Copper	Zn 65.38 Zinc	Ga 69.72 Gallium	Ge 72.61 Germanium	As 74.92 Arsenic	Se 78.96 Selenium	Br 79.90 Bromine	Kr 83.80 Krypton								
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54								
Rb 85.47 Rubidium	Sr 87.62 Strontium	Y 88.89 yttrium	Zr 91.22 Zirconium	Nb 92.91 Niobium	Mo 95.96 Molybdenum	Tc (98) Technetium	Ru 101.1 Ruthenium	Rh 102.9 Rhodium	Pd 106.4 Palladium	Ag 107.9 Silver	Cd 112.4 Cadmium	In 114.8 Indium	Sn 118.7 Tin	Sb 121.8 Antimony	Te 127.6 Tellurium	I 126.9 Iodine	Xe 131.3 Xenon								
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86								
Cs 132.9 Cesium	Ba 137.3 Barium	La 138.9 Lanthanum	Hf 178.5 Hafnium	Ta 180.9 Tantalum	W 183.9 Tungsten	Re 186.2 Rhenium	Os 190.2 Osmium	Ir 192.2 Iridium	Pt 195.1 Platinum	Au 197.0 Gold	Hg 200.6 Mercury	Tl 204.4 Thallium	Pb 207.2 Lead	Bi 209.0 Bismuth	Po (209) Polonium	At (210) Astatine	Rn (222) Radon								
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118								
Fr (223) Francium	Ra (226) Radium	Ac (227) Actinium	Rf (261) Rutherfordium	Db (262) Dubnium	Sg (266) Seaborgium	Bh (264) Bohrium	Hs (277) Hassium	Mt (268) Meitnerium	Ds (269) Darmstadtium	Rg (272) Roentgenium	Cn (285) Copernicium	Nh (284) Nihonium	Fl (289) Flerovium	Mc (288) Moscovium	Lv (292) Livermorium	Ts (294) Tennessine	Og (294) Oganesson								

58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm (145) Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium
90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np 237.0 Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (251) Californium	99 Es (252) Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

原子质量单位 Atomic mass unit 1.66054×10^{-27} kg

阿伏伽德罗常数 Avogadro's number 6.022×10^{23}

电子电荷量 Charge of an electron 1.60218×10^{-19} C

法拉第常数 Faraday's constant 96485 C mol⁻¹

理想气体常数 Gas constant $8.3145 \text{ J K}^{-1} \text{ mol}^{-1}$

电子质量 Mass of an electron 9.1094×10^{-31} kg

光速 Speed of light $2.99792458 \times 10^8 \text{ ms}^{-1}$

普朗克常数 Plank Constant 6.62637×10^{-34} Js

1 atm = 101325 Pa

1 bar = 100000 Pa

0 °C = 273.15 K

想要获得此项目最新最全真题，权威答案及测评功能，欢迎关注APASS详细了解。更有全真模考，不限次数，独家全真分数排名，匹配当年排行榜及所获奖项。即刻加入会员，超40项具有影响力的国际思维挑战趣味真题，激发学习兴趣，开拓视野，训练逻辑思维能力。

加入APASS会员方式：

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方式二：扫描下方二维码，登录阿思丹国际理科测评小程序报名

