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Question Booklet No.

QUESTION BOOKLET

CHEMICAL ENGINEERING

Booklet Series

A

Roll No. | | | | | |

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Time Allowed : 2 Hours **Maximum Marks : 100**

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1. _____ equation predicts the activity coefficient from experimental data.

[A] Lewis-Randall

[B] Margules

[C] Van Saar

[D] Uniquas

2. C_p of a gas at its critical temperature becomes

[A] zero

[B] unity

[C] infinity

[D] $7R/2$ (where R = Universal gas constant)

3. Mollier Diagram is a plot of

[A] temperature vs enthalpy

[B] temperature vs entropy

[C] enthalpy vs entropy

[D] temperature vs internal energy

4. Bernoulli's equation is a mathematical expression of

[A] the ratio of kinetic to viscous forces in a flow stream

[B] friction loss as fluid moves through a rough pipe

[C] potential and kinetic energies in a flow stream

[D] fluid density and compressibility in a restriction

5. In which of the following cases, it is possible for flow to occur from low pressure to high pressure?

[A] Flow of liquid in a diverging pipe

[B] Flow of liquid in a converging pipe

[C] Flow of air downward in a pipe

[D] In a constant cross-section conduit

6. The specific cake resistance for compressible sludges is a function of the pressure drop

[A] over cake

[B] over medium

[C] overall

[D] over filter medium

7. Trommels operate at

[A] high speed

[B] low speed

[C] intermediate speed

[D] very high speed

8. Rate determining step in a reaction consisting of a number of steps in series is the

[A] fastest step

[B] slowest step

[C] intermediate step

[D] step with highest rate

9. If ΔG (free energy change) for a chemical reaction is very large and negative, then the reaction is

[A] not feasible

[B] just feasible

[C] very much feasible

[D] ΔG is no measure of feasibility of a reaction

10. Condensation of a vapour under saturation condition means removal of

[A] latent heat

[B] sensible heat

[C] super heat

[D] None of the above

11. Heat transfer rate is maximum in

[A] laminar flow

[B] turbulent flow

[C] cocurrent flow

[D] countercurrent flow

12. Absorption coefficient is maximum for

[A] aluminium plate

[B] steel

[C] furnace refractories

[D] carbon lamp black

13. The diffusivity has same dimension as

[A] absolute viscosity

[B] kinematic viscosity

[C] density

[D] concentration

14. Which one of the following is ***not*** a diffusional process?

[A] Mass transfer

[B] Heat transfer

[C] Momentum transfer

[D] Molecular diffusion

15. Most expensive controller is

[A] P controller

[B] PI controller

[C] PID controller

[D] PD controller

16. A first-order instrument is

[A] two tanks connected in interacting mode

[B] vapour pressure thermometer (base type)

[C] two tanks connected in non-interacting mode

[D] U-tube manometer

17. Ammonia separation process is performed by

[A] absorption process

[B] distillation process

[C] diffusion process

[D] humidification process

18. Alcohol is dehydrated using _____ distillation.

[A] extractive

[B] steam

[C] azeotropic

[D] molecular

19. Mass transfer coefficient of liquid is

[A] affected more by temperature than that for gases

[B] affected much less by temperature than that for gases

[C] not affected by temperature

[D] None of the above

20. The percentage humidity is less than the relative humidity only at _____% humidity.

[A] 0

[B] 100

[C] 0 & 100

[D] <0

21. Nitrous oxide reacts with oxygen to form nitrogen dioxide in a reversible reaction given below :

$NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$, given that $\Delta_r G° = -81{\cdot}2$ kJ mol^{-1}.

The equilibrium constant at 25 °C for the reaction is

[A] $5{\cdot}91 \times 10^{-13}$

[B] 28·2

[C] 1·03

[D] 10^{14}

22. The specific heat capacity of air at constant pressure is $C_p = 26{\cdot}693$ J/mol-K and T is in kelvin. The heat given off by 1 mol of air, when cooled at 1 atmospheric pressure from 500 °C to –100 °C, is

[A] 10·73 kJ

[B] 16·89 kJ

[C] 16·01 kJ

[D] 18·33 kJ

23. For a spontaneous change in a system at constant temperature and pressure, which of the following statements is ***true***?

[A] $\Delta G < 0$

[B] $\Delta G = 0$

[C] $\Delta G > 0$

[D] There is no restriction on the value of ΔG

24. In a throttling process, the pressure of an ideal gas reduces by 50%. If C_p and C_v are the heat capacities at constant pressure and constant volume respectively ($\gamma = C_p/C_v$), the specific volume will change by a factor of

[A] 2

[B] $2^{1/\gamma}$

[C] $2^{\gamma-1/\gamma}$

[D] 0·5

25. Calculate the difference between the molar internal energy and the molar enthalpy for a perfect gas at 298·15 K.

[A] 35·859 J mol^{-1}

[B] 0 J mol^{-1}

[C] 2·4790 J mol^{-1}

[D] 8·3145 J mol^{-1}

26. A metallic block weighs 5 kg and has an initial temperature of 500 °C. The block is dropped in a tank containing 40 kg of water at 25 °C and left till the equilibrium is achieved. Specific heat of block material is 0·4 kJ-kg^{-1}-K^{-1}. The total entropy change in kJ-kg^{-1}-K^{-1} is

[A] –1·87

[B] 0

[C] 1·26

[D] 3·91

27. The dimensionless group in mass transfer that is equivalent to Prandtl number in heat transfer is

[A] Nusselt number

[B] Sherwood number

[C] Schmidt number

[D] Stanton number

28. The pressure drop across an orifice meter is overestimated by 5%. What will be the percentage error while measuring the flow rate?

[A] +2·47

[B] 5

[C] –2·47

[D] –5

29. Size reduction of coarse hard solids using a crusher is accomplished by

[A] attrition

[B] compression

[C] cutting

[D] impact

30. Lower BWG means _____ of the tube.

[A] lower thickness

[B] lower cross-section area

[C] outer diameter

[D] inner diameter

31. Dilute slurry is filtered at constant pressure to recover the solids. To reduce the time of filtration, the dilute slurry is initially evaporated to remove one-fourth of the solvent. If the resistance of the filter medium is neglected, filtration time will be reduced by a factor of

[A] 32

[B] 16

[C] 8

[D] 4

32. Water flows through a circular pipe having diameter 5 cm with a pressure of 2 bars and velocity of 2 m/s. The kinetic head of water is equal to

[A] 20·4 m

[B] 0·101 m

[C] 0·204 m

[D] 10·1 m

33. During the transient convective cooling of a solid object, the Biot number approaches 0. This indicates

[A] uniform temperature throughout the object

[B] negligible convection at the surface of the object

[C] significant thermal resistance within the object

[D] significant temperature gradient within the object

34. For flow of fluid over a heated plate, the following fluid properties are known :

Viscosity = 0·001 Pa-s; Specific heat at constant pressure = 1 kJ/kg-K; Thermal conductivity = 1 W/m-K.

The hydrodynamic boundary layer thickness at a specified location on the plate is 1 mm. The thermal boundary layer thickness at the same location is

[A] 0·001 mm

[B] 0·01 mm

[C] 1 mm

[D] 1000 mm

35. A hollow sphere of internal diameter ID = 20 cm and outer diameter OD = 30 cm contains hot fluid. What should be the critical radius of insulation for maximum rate of heat transfer? (Thermal conductivity k = 0·86 W/m-K and convection heat transfer coefficient of the outer fluid h_o = 20 W/m^2-K)

[A] 0·086 cm

[B] 0·86 m

[C] 8·6 mm

[D] 8·6 cm

36. A composite flat wall of a furnace is made up of two materials *A* and *B*. The thermal conductivity of *A* is twice that of *B*, while the thickness of layer of *A* is half that of *B*. If the temperatures at the two sides of the wall are 400 K and 1200 K, then the temperature drop (in K) across the layer of material *A* is

[A] 125

[B] 133

[C] 150

[D] 160

37. The formula for thermal resistance (R_k) of a spherical shell of inner and outer radii as r_i and r_o respectively (where k is the thermal conductivity), is

[A] $R_k = (r_i - r_o)/4\pi r_i r_o k$

[B] $R_k = 4\pi r_i r_o k / (r_i - r_o)$

[C] $R_k = (r_i - r_o)/4\pi k$

[D] $R_k = r_i r_o / 4\pi k (r_i - r_o)$

38. A hot liquid is to be cooled in a 1-1 shell and tube heat exchanger from 80 °C to 50 °C. Cooling water enters the tube side at 30 °C and exits at 45 °C. The properties of the liquids are constant. Also, the overall heat transfer coefficient is same for counter-current and co-current modes. The percentage saving in heat transfer area for counter-current option with respect to the area of co-current option is

[A] 22·12

[B] 36·32

[C] 27·10

[D] 44·50

39. If the distillation is operating at total reflux, the distillation column requires minimum

[A] reboiler load

[B] condenser load

[C] number of plates

[D] diameter of column

40. The flooding velocity in a plate column operating at 1 atm pressure is 3 m/s. If the column is operated at 2 atm pressure under otherwise identical conditions, the flooding velocity will be

[A] $3/\sqrt{2}$

[B] 3/2

[C] 1

[D] 3/4

41. If the relative humidity is 90% and temperature is 25 °C, the water evaporates from the surface of a water body at a rate of 1·0 kg/m^2-h. The RH that will lead to an evaporation rate of 3·0 kg/m^2-h, with other conditions remaining same, is

[A] 30%

[B] 50%

[C] 60%

[D] 70%

42. Stanton number for mass transfer is defined as

[A] Schmidt number / (Sherwood Number × Re)

[B] Re / (Schmidt Number × Sherwood Number)

[C] (Re × Sherwood Number) / Schmidt Number

[D] Sherwood Number / (Re × Schmidt Number)

43. Consider the reaction

$$A \xrightarrow{k_1 (1\text{st order})} R \xrightarrow{k_2 (1\text{st order})} S$$

R is the desired product. Step (1) has activation energy of 20 kcal/mol and Step (2) has activation energy of 10 kcal/mol. In order to promote the production of R, the reaction should be conducted

[A] at the lowest possible temperature

[B] at the highest possible temperature

[C] at an intermediate temperature (between the highest and the lowest temperature)

[D] in accordance with a temperature progression; low temperature followed by high temperature

44. A plot of ln k vs $1/T$, where k is the rate constant is known as

[A] Bode diagram

[B] van't Hoff plot

[C] Arrhenius plot

[D] heat flow diagram

45. The vapour pressures of toluene are 6·811 kPa at 310 K and 24·15 kPa at 340 K. Assuming that the variation of the vapour pressure P with temperature T may be described by the expression

$$\log(P) = A - \frac{B}{T}$$

where P is in kPa. What are the values of A and B?

[A] $A = 7{\cdot}059$, $B = 1930$ K

[B] $A = 5{\cdot}307$, $B = 1930$ K

[C] $A = 6{\cdot}971$, $B = 7780$ K

[D] $A = 5{\cdot}307$, $B = 7780$ K

46. For a chemical reaction, the ratio of rate constant at 500 K to that at 400 K is 2·5. Given $R = 8{\cdot}314$ J-mol^{-1}-K^{-1}, the value of activation energy (in kJ/mol) is

[A] 10·5

[B] 12·0

[C] 15·2

[D] 18·4

47. Gas chromatography is used for the measurement of

[A] temperature

[B] pressure

[C] concentration

[D] flow rate

48. The working principle of a Pirani gauge is based on

[A] change in thermal conductivity

[B] change in ionization potential

[C] deformation of elastic body

[D] change in inductance

49. The flapper nozzle is the primary device for all _____ instruments.

[A] electronic

[B] hydraulic

[C] pneumatic

[D] electrical

50. A system demonstrates inverse response for a unit step change in the input. Which one of the following is ***true*** for such a system?

[A] The transfer function of the system has at least one negative pole

[B] The transfer function of the system has at least one positive pole

[C] The transfer function of the system has at least one negative zero

[D] The transfer function of the system has at least one positive zero

51. In a chemical process plant, utilities include steam, water, compressed air, electricity, oxygen, fuel gases etc. The cost of utilities in a common chemical process plant is roughly what percentage of the total product cost?

[A] 1 to 5

[B] 10 to 20

[C] 25 to 35

[D] 35 to 40

52. A company issues bonds worth INR 5,00,000 having a coupon rate of 10% and maturing in 10 years. The company has set up sinking fund method to pay off the bonds. The coupons are to be paid biannually at an interest rate of 6%. The periodic payment of coupon will be in INR

[A] 40,096·25

[B] 18,607·85

[C] 15,000·00

[D] 17,980·00

53. The major component of Chemical Engineering Plant Cost Index is

[A] fabricated equipment and machinery

[B] process instruments and control

[C] pumps and compressor

[D] electrical equipment and material

54. In case of a multiple effect evaporator, the optimum number of effects is decided using

[A] cost-benefit analysis

[B] floor area availability

[C] terminal parameters

[D] evaporation capacity required

55. Which of the following methods is commonly used to commercially produce ethylene from naphtha?

[A] Catalytic cracking

[B] Catalytic dehydrogenation

[C] Pyrolysis

[D] Hydrocracking

56. Which of the following is undesirable in gasoline but desirable in kerosene?

[A] Aromatics

[B] Mercaptans

[C] Naphthenic acid

[D] Paraffins

57. The material used to give blue coloration to glass is

[A] NiO

[B] CoO

[C] $FeSO_4$

[D] CdS

58. Antioxidants are added to rubber to protect it from the attack of light, heat and atmospheric ozone. Which of the following is an antioxidant used in rubber?

[A] Carbon

[B] Alkylated diphenylamine

[C] Thiokol

[D] Magnesium

59. Butyl rubber is a copolymer of

[A] 1-butene with a small amount of isobutene

[B] isobutene with a small amount of 2-methyl butadiene (isoprene)

[C] butadiene with a small amount of propylene

[D] 1-butene with a small amount of butadiene

60. Wood and cotton are mostly made up of

[A] glucose monomers linked up in a polymer

[B] polyisoprene

[C] polysaccharides called cellulose

[D] amino acids in the form of polypeptides

61. The dynamic viscosity of water at room temperature will be close to unity in which of the following units?

[A] Poise

[B] Centistoke

[C] Milli N-s/m^2

[D] Pa-s

62. Purging is necessary in the production of ammonia because

[A] nitrogen is in excess

[B] argon gets accumulated

[C] reactants are not in stoichiometric proportions

[D] conversion is not 100%

63. The coefficient of performance (COP) of a Carnot heat pump operating between T_1 and T_2 (such that $T_1 > T_2$) is given by

[A] $T_2/(T_1-T_2)$

[B] T_1/T_2

[C] $T_1/(T_1-T_2)$

[D] T_2/T_1

64. For the fully developed laminar flow through the parallel plates, the ratio of maximum velocity to that of average velocity is

[A] 2

[B] $\sqrt{2}$

[C] 4/3

[D] 3/2

65. For the flow measurement of a canal, which device is used?

[A] Rectangular weir

[B] Venturimeter

[C] Pitot tube

[D] Rotameter

66. A centrifugal pump having an impeller of diameter 120 mm, delivers a power of 12 HP. If the diameter of impeller is halved, what is the power, if other parameters are kept constant?

[A] 6 HP

[B] 2 HP

[C] 4 HP

[D] 3 HP

67. The apparent viscosity of a fluid is given by $0{\cdot}007\left(\frac{dV}{dY}\right)^{0{\cdot}3}$, where $\left(\frac{dV}{dY}\right)$ is the velocity gradient. The fluid is

[A] Bingham plastic

[B] dilatant

[C] pseudoplastic

[D] thixotropic

68. Where the density difference of the two liquid phases to be separated is very small (as in milk cream separator), the most suitable separator is a

[A] tubular-bowl centrifuge

[B] disc-bowl centrifuge

[C] suspended batch basket centrifuge

[D] perforated horizontal basket continuous centrifuge

69. A cross-flow type air heater has an area of 50 cm^2. The overall heat transfer coefficient is 100 W/m^2-K and heat capacity of both hot and cold steam is 1000 W/m-K. The value of NTU is

[A] 0·2

[B] 6·0

[C] 1000

[D] 5·0

70. A heat exchanger shell of outside radius 15 cm is to be insulated with glass wool of thermal conductivity 0·0825 W/m degree Celsius. The temperature at the surface is 280 degree Celsius and it can be assumed to remain constant after the layer of insulation has been applied to the shell. The convective film coefficient between the outside surface of glass wool and the surrounding air is estimated to be 8 W/m^2 degree Celsius. What is the value of a critical radius?

[A] 9·31 mm

[B] 10·31 mm

[C] 11·31 mm

[D] 12·31 mm

71. Controlling heat transfer film coefficient is the one which offers _____ resistance to heat transfer.

[A] no

[B] the least

[C] the largest

[D] lower

72. The advantage of backward-feed multiple effect evaporators over forward-feed evaporators is that

[A] heat sensitive materials can be handled

[B] there is no additional cost of pumping

[C] most concentrated liquor is at highest temperature

[D] equal heat transfer coefficients exist in various effects

73. In pool-boiling, the highest heat transfer coefficient occurs in

[A] subcooled boiling zone

[B] nucleate boiling zone

[C] partial film boiling zone

[D] film boiling zone

74. Find the time taken to dry 50% to 40% of moisture (dry basis) if critical moisture content is 30%. (If the weight of the wet solid is 5 kg and the product of area and the constant rate is 0·5 kg/min)

[A] 20 sec

[B] 40 sec

[C] 60 sec

[D] 80 sec

75. For a saturated liquid-vapour mixture, if the liquid flow rates inside the enriching and the stripping section of a fractionator are 30 mol/hr and 20 mol/hr respectively and also the feed rate is 10 mol/hr, find the feed condition.

[A] Saturated vapour

[B] Saturated liquid

[C] Superheated vapour

[D] 50% vapour

76. For the nth tray (counted from the top of distillation column), the Murphree tray efficiency is given by

[A] $\frac{Y_{n+1} - Y_n}{Y_n^* - Y_{n-1}}$

[B] $\frac{Y_n - Y_{n+1}}{Y_n^* - Y_{n+1}}$

[C] $\frac{Y_{n-1} - Y_n}{Y_{n+1} - Y_{n-1}}$

[D] $\frac{Y_n^* - Y_{n-1}}{Y_n^* - Y_{n+1}}$

77. Liquid redistributors are necessary in packed towers to avoid

[A] flooding

[B] weeping

[C] channelling

[D] coning

78. For gas phase controlled mass transfer, which one is ***not*** true?

[A] The gas is readily soluble in liquid

[B] The gas is sparingly soluble in liquid

[C] The equilibrium curve is flat

[D] Overall resistance to mass transfer is equal to the resistance on gas side

79. If the operating line coincides with the equilibrium curve, which one of the following is ***not*** true for absorbers?

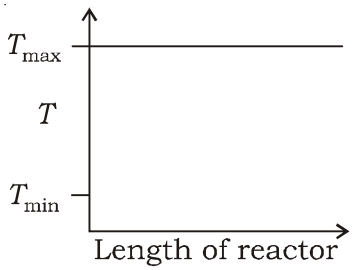
[A] The solvent rate is minimum

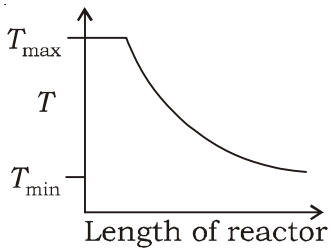
[B] The number of plates is infinity

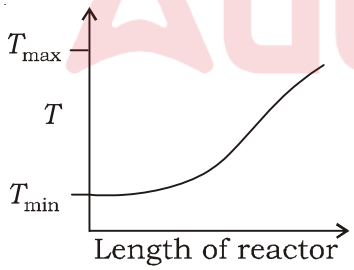
[C] The L/G ratio is maximum

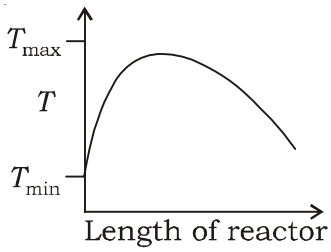
[D] The driving force becomes zero

80. Consider a reversible reaction in a plug flow reactor. The maximum and minimum permissible temperatures are T_{max} and T_{min} respectively. Which of the following temperature (T) profiles will require the shortest residence time to achieve the desired conversion?

[A]


[B]


[C]


[D]


81. For which reaction order, the half-life of the reactant is half of the full lifetime (time for 100% conversion) of the reactant?

[A] Zero order

[B] Half order

[C] First order

[D] Second order

82. If Thiele modulus is _____, then the pore diffusion resistance in a catalyst may be considered as negligible.

[A] > 0·5

[B] ∞

[C] < 0·5

[D] 0

83. For the irreversible reactions $A \xrightarrow{k_1} R$ and $A \xrightarrow{k_2} S$, the rate of disappearance of A is given by

[A] $(k_1 - k_2)C_A$

[B] $(k_1 + k_2)C_A$

[C] $0{\cdot}5(k_1 + k_2)C_A$

[D] $k_1 C_A$

84. The conversion of a first order liquid-phase $A \rightarrow B$ in an ideal continuous stirred tank reactor (CSTR) is 50%. If another ideal continuous stirred tank reactor (CSTR) of the same volume is connected in series, then % conversion at the exit of second reactor will be

[A] 60

[B] 75

[C] 90

[D] 100

85. The open-loop transfer function of a unity-gain feedback control system is given by

$$G(s) = \frac{K}{(s+1)(s+2)}$$

The gain margin of the system in dB is

[A] 0

[B] 1

[C] 2

[D] ∞

86. Which one of the following sensors is used for the measurement of temperature in a combustion process ($T > 800$ °C)?

[A] Type J thermocouple

[B] Thermistor

[C] Resistance temperature detector

[D] Pyrometer

87. Which of the following is a static characteristic of instrument?

[A] Fidelity

[B] Dynamic error

[C] Reproducibility

[D] Speed of Response

88. An example of an open-loop second order underdamped system is

[A] liquid level in tank

[B] U-tube manometer

[C] thermocouple in a thermo-well

[D] two non-interacting first order systems in series

89. A first order system with unity gain and time constant τ is subjected to a sinusoidal input of frequency $\omega = 1/\tau$. The amplitude ratio for this system is

[A] 1

[B] $\frac{1}{2}$

[C] $1/\sqrt{2}$

[D] $\frac{1}{4}$

90. The circumferential (hoop) stress in a thin walled cylindrical vessel under internal pressure is

[A] $\frac{pd}{2t}$

[B] $\frac{pd}{t}$

[C] $\frac{pd}{3t}$

[D] $\frac{pd}{4t}$

91. The term 'knuckle radius' is associated with

[A] flat heads

[B] torispherical heads

[C] hemispherical heads

[D] conical heads

92. For a given fluid, as the pipe diameter increases, the pumping cost

[A] decreases

[B] increases

[C] remains the same

[D] may increase or decrease, depending upon whether the fluid is Newtonian or non-Newtonian

93. A five-year asset which had an initial cost of ₹2,00,000 with a salvage value of ₹20,000, was depreciated by the straight line method. The book value of asset at the end of four years will be

[A] ₹36,000

[B] ₹42,000

[C] ₹48,000

[D] ₹56,000

94. Direct cost component of the fixed capital consists of

[A] contingencies

[B] onsite and offsite costs

[C] labour costs

[D] raw material costs

95. With increase in the discounted cash flow rate of return, the ratio of the total present value to the initial investment of a given project

[A] decreases

[B] increases

[C] increases linearly

[D] remains constant

96. For the hydrogenation of oils, _____ is used as a catalyst and _____ is a catalyst poison.

[A] platinum, sulphur

[B] platinum, oxygen

[C] nickel, sulphur

[D] nickel, oxygen

97. Styrene is produced from ethyl-benzene by

[A] dehydrogenation

[B] alkylation

[C] oxidation

[D] dehydration

98. In the Fluid Catalytic Cracker (FCC), the cracking reaction is _____ and the regeneration reaction is _____ respectively.

[A] exothermic, endothermic

[B] endothermic, endothermic

[C] exothermic, exothermic

[D] endothermic, exothermic

99. The final boiling points of gasoline, diesel, atmospheric gas oil (AGO) and lubricating oils vary as

[A] gasoline > diesel > AGO > lubricating oils

[B] lubricating oils > AGO > diesel > gasoline

[C] AGO > lubricating oils > diesel > gasoline

[D] lubricating oils > diesel > AGO > gasoline

100. Triple superphosphate is manufactured by reacting

[A] phosphate rock with phosphoric acid

[B] phosphate rock with sulphuric acid

[C] phosphate rock with nitric acid

[D] ammonium phosphate with phosphoric acid

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