國立雲林科技大學
95 學年度博士班招生入學考試試題

所別：化學工程系
科目：化工熱力學

1. A gas at pressure and temperature of P_1 and T_1, respectively, is steadily exhausted to the atmosphere at P_2 through a pressure-reducing valve. Find an expression relating the downstream gas temperature T_2 to P_1 , P_2 , T_1.（20%）

2. Develop expressions for the coefficient of Joule-Thomson coefficient and the difference C_p - C_v for the gas that obeys van der waals equation.（30%）

3. Air at 101 kPa, 27℃, is compressed to 2000 kPa at a rate of 4 kg/s. Find the power of the compressor and the rate of heat removal for: （20%）

(a) Reversible isothermal compression.

(b) Reversible adiabatic compression.

Air may be considered as an ideal gas for which k (= C_p/C_v) = 1.4 and M = 29.

4. A binary solution of components A and B, at P_o = 10 MPa, T = 30℃, and mole fraction of component A, X_A = 0.98, is in equilibrium with a phase of pure A, through a membrane permeable to A only. The Gibbs free energy for this solution is given by

$$g = C_A X + C_B (1-X) + RT [X \ln X + (1-X) \ln (1-X)]$$

where C_A = 3000 kJ/kmol

C_B = 3000 kJ/kmol

R = 8.3143 kJ/kmol K

and X is the mole fraction of component A. Assume the specific volume of pure A is constant at V_A = 0.02 m^3/kmol. （30%）

(a) Interpret the meaning of the constants C_A and C_B.

(b) Is this solution ideal?

(c) Find the pressure of a phase of pure A which is in equilibrium with the solution.

國立雲林科技大學
95學年度博士班招生入學考試試題

所別：化學工程系
科目：化學工程文獻

本試題共兩大題，每題50分。

一、　附件一之文獻出自 Science 期刊，篇名是 "Key to cheaper, better nanotubes comes out in the wash"，共有6段落。請針對「附件一」內容，回答以下問題：

1. 請將文章第一及第六段內容翻譯成中文。
2. 奈米碳管之製備方法包括那些？請簡述之。
3. 製備奈米碳管時，有什麼方法可用以避免 amorphous carbon 之污染，進而提升奈米碳管之成長效率？

二、針對「附件二」文章（Mass Transfer）內容，回答下列4小題：

1. （10%）根據附件文章（Mass Transfer）之敘述，何謂 mass transfer？發生之機制及目的為何？（註：請以中文回答，否則不與計分）
2. （15%）請將附件文章（Mass Transfer）第二段翻譯成中文。
3. （15%）根據附件文章（Mass Transfer）之敘述，請說明在生物與化學製程上，有哪些實例會運用到 mass transfer？（註：請以中文回答，否則不與計分）
4. （10%）請將附件文章（Mass Transfer）第四段第一句翻譯成中文。

Mass Transfer. When a system contains two or more component whose concentrations vary from point to point, there is a natural tendency for mass to be transferred, minimizing the concentration differences within the system. The transport of one constituent from a region of higher concentration to that of a lower concentration is called ***mass transfer***.

Many of our day-by-day experiences involve mass transfer. A lump of sugar added to a cup of black coffee eventually dissolves and then diffuses uniformly throughout the coffee. Water evaporates from ponds to increase the humidity of the passing air stream. Perfume presents a pleasant fragrance which is imparted throughout the surrounding atmosphere.

Mass-transfer is the basis for many biological and chemical processes. Biological processes include the oxygenation of blood and the transport of ions across membranes within the kidney. Chemical processes include the chemical vapor deposition (CVD) of silane (SiH_4) onto a silicon wafer, the doping of a silicon wafer to form a semiconducting thin film, the aeration of wastewater, and the purification of ores and isotopes. Mass transfer underlies the various chemical separation processes where one or more components migrate from one phase to the interface between two phases in contact. For example, in adsorption or crystallization processes, the components remain at the interface, whereas in gas absorption and liquid-liquid extraction processes, the components penetrate the interface and then transfer into the bulk of the second phase.

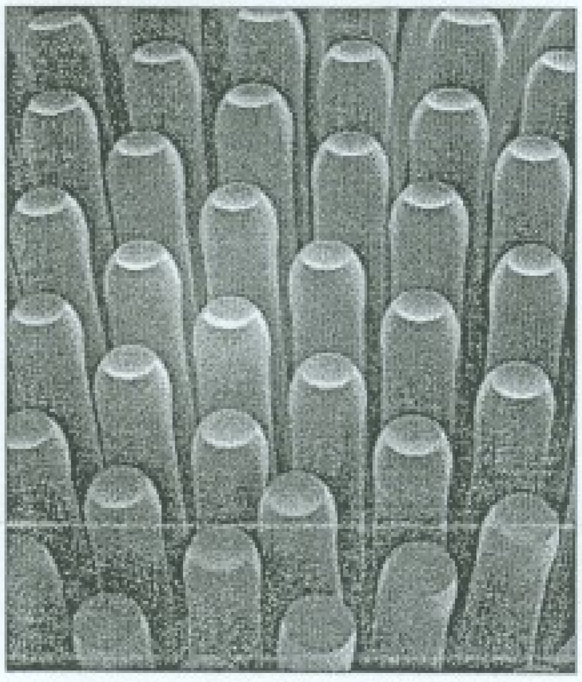
If we consider the lump of sugar added to the cup of black coffee, experience teaches us that the length of time required to distribute the sugar will depend upon whether the liquid is quiescent or whether it is mechanically agitated by a spoon. The mechanism of mass transfer, as we have also observed in heat transfer, depends upon the dynamics of the system in which it occurs. Mass can be transferred by random molecular motion in quiescent fluids, or it can be transferred from a surface into a moving fluid, aided by the dynamic characteristics of the flow. These two distinct modes of transport, molecular mass transfer and convective mass transfer, are analogous to conduction heat transfer and convective heat transfer.

化工文獻附件 —

MATERIALS SCIENCE

Key to Cheaper, Better Nanotubes Comes Out in the Wash

Since their discovery 13 years ago, carbon nanotubes have been nanotechnology's poster child. The tiny straw-shaped molecules are stronger than steel, flexible, and conductive. Researchers have pitched them as the right stuff for everything from chemical sensors and drug-delivery agents to wires for nanoscale computer circuitry and even the building blocks for an elevator extending into space. Their cost, however, is a bit of a problem: At $500 per gram, nanotubes are more than 30 times as expensive as gold. But that price may soon be on its way down.



Aquaculture. New water-based technique can grow luxuriant columns made of nanotubes.

On page 1362, Japanese researchers report that by simply adding a little water vapor to a standard nanotube production scheme, they've hit upon a new, highly efficient way to grow nanotubes. If the approach can be scaled up, it could significantly drop the price of nanotubes, opening the door to new commercial applications. The team also reports that the technique makes it straightforward to create macroscale sheets, pillars, and other shapes out of nanotubes, which could become the starting materials for novel types of electronic devices. "The results are quite remarkable and will lead to much follow-up," says Hongjie Dai, a chemist and nanotube expert at Stanford University.

In 1991, Japanese physicist Sumio Iijima discovered that nanotubes had grown on the cathode of an arc discharge machine used to make spherical, all-carbon molecules called fullerenes. The machine, which blasts a target of graphitic carbon with a jolt of electricity, turns out a jumble of tubes and soot. Today, most nanotube makers grow their minuscule tubes with the help of tiny nanosized catalyst particles that seed the growth of the tubes inside high-temperature vacuum chambers. The main drawback to this approach is that the resulting tubes wind up contaminated with catalyst particles, which must then be removed through chemical reactions.

In recent years, Iijima, now at the National Institute of Advanced Industrial Science and Technology in Tsukuba, and colleagues have focused on a simple nanotube manufacturing technique called chemical vapor deposition, in which hydrocarbon gases are fed into a superheated chamber containing nanoparticle catalysts. Like other groups, Iijima and his colleagues found that after only about 1 minute of operation, virtually all of the catalysts stopped working. The researchers knew that the high heat broke apart the hydrocarbons, creating a vapor of carbon atoms that link together to form the tubes. The trouble is that the tube must start growing correctly from the catalyst right from the start. Yet in most cases carbon atoms cover the catalyst particles with an amorphous coating that prevents nanotubes from taking shape.

Other researchers had found that they could remove the amorphous carbon simply by adding pure oxygen. But it works a little too well and quickly oxidizes—or burns—the growing nanotubes. "So we figured we need a weak oxidizer that will not damage the carbon nanotubes," says Kenji Hata, the physicist who led the current effort. The group decided to look at water, Hata says, because water readily reacts with carbon to create carbon monoxide and molecular hydrogen. Hata found that when he tuned his apparatus to add about 100 parts per million of water to ethylene and other inert carrier gases, the water reacted with the amorphous carbon from the catalyst particles but didn't damage the growing nanotubes. As a result, virtually all of the catalyst particles remained active and quickly produced a forest of nanotubes growing up from a surface. And because of the high efficiency of the growth process, the resulting crop of nanotubes ends up nearly free of catalyst contaminants.

By starting with catalysts patterned in circles and lines, the researchers grew both pillars and sheets of nanotubes. Because nanotubes have such unique optical, electrical, and thermal properties, patterned tubes may enable researchers to make devices such as optical filters and arrays of electron emitters for flat-panel displays, Hata says.

—ROBERT F. SERVICE

CREDIT: K. HATA ET AL./SCIENCE

ScienceScope

NIAID Tackles Flu Genomes

Hoping to spur the field of influenza research, the National Institute of Allergy and Infectious Diseases (NIAID) this week announced a new flu genome sequencing project. The $2-million-plus effort will crank through the sequences of thousands of human and avian influenza viruses and deposit them in GenBank, the public DNA database.

Because flu viruses constantly mutate, a new vaccine has to be designed each year for flu season. Having many more sequences on hand will help researchers explore why certain strains are more virulent and improve vaccines and drugs, NIAID officials say. "There's not a lot of sequence out there in the public domain," says the agency's Maria Giovanni. Researchers can also use the data to study how readily a human virus will combine with an avian flu strain, such as the H5N1 strain in Asia, and potentially touch off a global pandemic. The project—part of a broader NIAID microbial sequencing initiative based at The Institute for Genomic Research in Rockville, Maryland—will include collaborators such as flu expert Robert Webster's lab at St. Jude Children's Research Hospital in Memphis, Tennessee.

In another push to prepare for a pandemic, public health experts, government officials, and companies met last week for 2 days at the World Health Organization in Geneva. They called for governments to put up more money for pandemic vaccine development.

—JOCELYN KAISER AND GRETCHEN VOGEL

Infusion for Gulf War Sudies

In a move sure to spur debate, the Department of Veterans Affairs (VA) will spend up to $15 million over the next year on research into Gulf War illnesses, with an emphasis on the role of neurotoxins. The decision, announced on 12 November, follows a key recommendation made by a VA advisory panel that examined ailments arising from the 1990–91 Gulf War (*Science*, 1 October, p. 26).

The panel, chaired by former Defense Department official and Vietnam veteran James Binns, found a "probable link" between the symptoms experienced by Gulf War veterans and toxins that affect the nervous system, such as sarin gas and pesticides. Other committees, in particular those appointed by the Institute of Medicine (IOM), have rejected the neurotoxin hypothesis.

Harold Sox, editor of the *Annals of Internal Medicine* and a member of an IOM Gulf War committee, says the new studies aren't likely to settle the issue because researchers lack good epidemiologic information on what Gulf War troops were exposed to on the battlefield.

—JENNIFER COUZIN

Published by AAAS